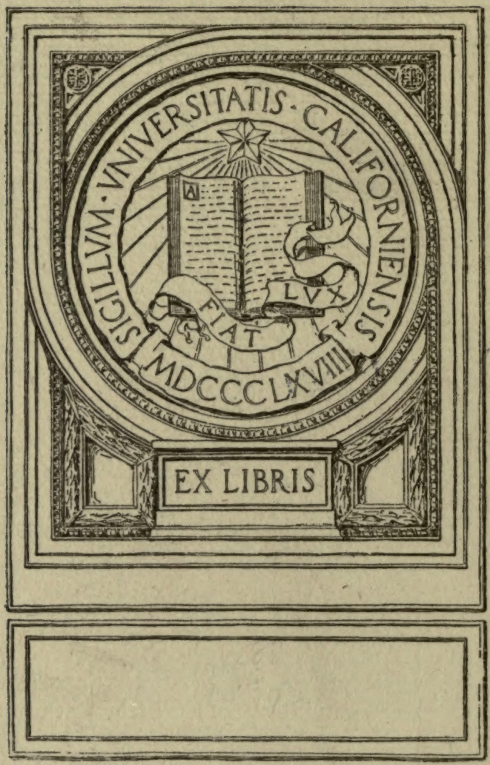
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NAVAL HYGIENE

PRYOR

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BY

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PREFACE

This work is offered to those members of the medical profession whose path of duty lies on the trackless seas with the hope that the author's effort to supply a want will offset any short-comings on his part.

Experience in teaching naval hygiene at the U. S. Naval Medical School has demonstrated to the writer the need of a student's manual of elementary character, hence this attempt to supply it.

To prepare a guide to a subject so comprehensive and so important in its bearing upon the welfare and efficiency of a naval personnel requires knowledge derived from actual extended service at sea.

Experience gained from years of naval service in all parts of the world has given the writer an advantage over fellow-students who have not lived afloat, and this leads him to hope that the work may find favor not alone as a guide, but as an incentive to further study of the maintenance of health and improvement of living conditions afloat.

None appreciates more than the writer the breadth of the subject. None can appreciate more than he the difficulty in treating it, especially at this time when certain phases of naval life are undergoing interesting development, owing to our participation in the great war. A free discussion of certain of these phases, however, must be left to the future, for the good of the service.

The author has drawn upon all available sources of information, and has tried to give due credit in the text, without exception; any oversight in this regard will be deeply regretted by him. He has obtained historical data from the Encyclopedia Britannica. To Rear-Admiral E. R. Stitt, Medical Director, U. S. N., commanding the United States Naval Medical School; Medical Director R. M. Kennedy, U. S. N.; Medical Director C. H. T. Lowndes, U. S. N.; to numerous other naval medical officers, and to Mr. William Henry Siviter, the author is indebted for assistance and advice.

Naval Constructor J. D. Beuret, U. S. N., has kindly furnished certain illustrations and Pharmacist's Mate, 3d Class, J. H. MacPherson, U. S. N., has supplied some of the drawings.

The writer is deeply grateful to his wife for making the index—a most tedious task—and for sustained facilitation throughout the preparation of the manuscript.

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NAVAL HYGIENE

CHAPTER I

INTRODUCTORY

Hygiene is that branch of medical science which concerns itself with the preservation of the health of individuals and communities. It aims to render "Growth more perfect, decay less rapid, life more vigorous, death more remote."

Hygiene is concerned with all the agencies which pertain to or affect the physical condition or mental state of man in his diverse environment.

In its broader sense Hygiene comprises many varieties. The special object of this book is a consideration of *Naval Hygiene*, including camp sanitation, conservancy, and personal hygiene.

To study intelligently the complex problems which render "Growth more perfect, decay less rapid, life more vigorous, and death more remote," naval medical officers must orient themselves and realize their duties require today that they care for men aboard ship and tomorrow men in camp or barracks ashore. The sailor man's duties take him ashore, afloat, in the air (aviation) and under water (submarines, diving).

The application of the principles of hygiene and the interpretation of the results of their operation are not spectacular. Results are achieved slowly, so slowly that often they are accepted by the laity as matter of fact without appreciation of what are in reality splendid results.

In commencing a study of Hygiene and Preventive Medicine it is well to bear in mind that the results of application of their principles are not always immediately manifest.

Many lack patience to work in this field where a richer harvest may reward their years of toil than can be reaped by them on ground where the objective and the spectacular yield smaller results more

quickly. It is not an extravagance to estimate that fully 95 per cent. of the aspirants for the degree of Doctor of Medicine have been inclined to become surgeons because of attraction by surgery's spectacular achievements. How often does one see medical cases referred to a distinguished surgeon, not because such cases are desired by the surgeon or interest him, but because his splendid spectacular success has attracted the attention of the layman who does not exercise nice discrimination in his choice!

The surgeon's patient gets relief, cure, or a coffin. The patient of the skilled medical colleague shows far less quick result, being nursed back to health slowly, or gradually life's tide ebbs, to come to a flood no more.

The worker in the field of Hygiene and Preventive Medicine has far less of the spectacular to attract attention of a busy public than the surgeon, or than even the medical practitioner.

Years of broad and painstaking observation are required for the expression of results of his endeavor along any line, and even after these results are manifest few stop to translate into comprehensible terms the figures by which the results gain expression.

For instance, in the registration area for deaths in the United States the mortality rate per 1000 in 1914 was 13.6, while in 1915 the rate per 1000 in the same area was 13.5, a decrease in rate of 0.1 per 1000. The estimated population of the registration area for deaths in the United States in 1915 was 67,333,992. When the 0.1 per 1000 decrease in rate is applied to the above-estimated population it is found that there were nearly 7000 fewer deaths in the registration area in 1915 than in 1914. Obviously it would be illogical to attribute this saving of 7000 lives wholly to prophylaxis, although it must be conceded that preventive measures have played the principal rôle.

The following is a striking instance illustrative of what has been accomplished by prophylaxis in the United States Navy with reference to the prevalence of typhoid fever.

In 1912 the administration of anti-typhoid prophylactic became compulsory in the Navy. All persons under forty-five years of age were required to be inoculated except those who gave history of having had typhoid fever. Those over forty-five years of age were exempt.

During the decennium immediately preceding the commencement of compulsory inoculation the average of the annual morbidity rates for the ten years was 4.11 per 1000, and the average number of actual

deaths yearly was 14.9, regardless of annual strength, or population. Since compulsory inoculation the average number of deaths from typhoid fever (regardless of strength) in the Navy has been 1.25 per year. The difference of these mortality averages indicates that 13.65 lives probably have been saved each year through compulsory anti-typhoid inoculation.

Since 1912 (the year during which the prophylactic was being administered) the average annual rate per 1000 for admission to the sick list for typhoid fever has been 0.25, as against 4.11, the average rate for the preceding ten years.

The total average strength of the Navy and Marine Corps in 1916 was 69,294 men. Applying the average rate per 1000 before inauguration of compulsory anti-typhoid inoculation we have 69,294 times 4.11 = 284.79 cases which might have been expected in 1916. Only 17 cases appear in the official records.

Further than this, there has been a great reduction in case rate, corresponding suffering, and economic loss during this period.

A faithful observance of prophylactic measures has rendered it possible to prevent many of the diseases which hitherto have scourged camps: Malaria, yellow fever, typhus, typhoid, relapsing fever, cholera, dysentery, diphtheria, and others that might be mentioned have been forced to yield to the principles of preventive medicine, and are no longer the dread scourges that once stalked through camp and claimed their tribute of stalwart men. In all wars of which we have accurate data, except the Russo-Japanese War, there have been about six deaths from disease to every death caused by injury; in other words, *disease is a far more formidable foe to fighting forces than the enemy's shot and shell.*

CHAPTER II

HISTORICAL

Our knowledge of the hygienic conditions of ships in ancient times is incomplete and we are in want of contemporaneous record to give us data of value concerning the living conditions.

In all this period of oar-driven vessels naval hygiene had not developed. The hygienic conditions were very unsatisfactory from our viewpoint. Just in the self-same manner the fishing boats of today are not properly cared for from the standpoint of naval hygiene.

In earliest time the voyage was short and only coastwise. Landings were often made, and therefore opportunities were frequent for replenishment of the provision lockers and for getting water. The influence of the nautical habitation tended to change of thought and diversion, because of the need for these landings, at frequent intervals.

In earlier vessels we see a development from:
Rafts, or logs tied together; to the
Dugout (merely a hollowed log); then the
Canoe (built of skin or bark, having greater carrying capacity); followed by the
Canoe of wood (with outriggers and sails); then
Vessels of planks and ribs and oars; then sails; and then steam.

The exact time to which these developmental periods may be referred is obscured in the mists of antiquity.

Dugouts of the Stone Age have been found 25 feet below the surface of the earth in England.

Egyptian vessels (3000 B.C.) carried men and cattle, had masts and from 22 to 26 oars. They were 180 feet long.

The ship in which St. Paul and his companions were wrecked carried 276 souls besides the cargo.

The Phœnicians developed biremes and triremes, and Greek literature tells us that some of the Phœnician vessels carried 120 men.

The fragile construction of the earlier ships did not allow navigation in heavy weather, the lack of a mariner's compass kept them near to land, and these vessels, constructed with a flat keel were frequently dragged ashore and did not constitute a habitation for the men who lived in the open air.

After this frail craft followed the vessels with sails, necessary for distant navigation and for voyages of exploration guided by the newly discovered mariner's compass across the trackless deep.

Then the navigators of the Mediterranean began to venture into the Atlantic, discovering Madeira, Cape of Good Hope, America, etc.

In order to meet the demands made by long voyages naval architecture underwent great changes, and ships became permanent habitations for their crews; in order to resist the force of the waves ships were built much stronger, and to enable the carrying of cargo and guns displacement was increased. The substitution of sails for oars permitted closure of the deck except at the middle hatch. Bridges and superstructures multiplied, the draft increased, and the hold was constantly closed during the voyage. There was darkness without ventilation and these vessels always contained a quantity of stagnant water.

The first representative vessels were caravels, small air-propelled ships which had a single deck and two high citadels, one at either extremity, with a crew of 50 men. More slowly another deck was added.

Next followed caracks and galleons with more superstructure for transporting passengers. The caracks had 4 decks and 2 large citadels at the ends; the galleons 2 decks and 14 gun ports on a side.

During the Crusades vessels of wood, large and small, carrying men armed with pikes and cutlasses were used.

Gunpowder commenced to be used about this time (shortly after the Crusades) and had a great influence on naval architecture. As a result, ships commenced to grow in size and even in protective arrangement of construction, for with gunpowder came a change in type of combat.

The Spanish Armada consisted of 132 ships which varied from 100 to 1300 tons. When it is realized that these were all wooden vessels it may be imagined that a 1300-ton vessel was one of considerable size.

In the 18th century a 90-gun ship of the line was about 160 feet long, and of large displacement.

Until the middle of the 19th century ships, corvettes, frigates, and brigantines were the war vessels. Ships of 3 masts and much more numerous vessels of smaller type constituted the merchant marine. A ship of 3 decks displaced about 3000 tons. But the necessity of carrying enough ammunition and stores, and the more numerous crews that were required to sail and fight these ships, caused gradual increase in size of the vessels.

In addition, the long voyage without possibility of intermediate stop necessitated the carrying of abundant provisions which added to the difficulty. The supply of water expected to last about two months was calculated solely upon a minimum ration of 1 liter per day.

Concerning this condition of living the Italian voyageur, Grenelli Careri, describes a voyage to Manila and Acapulco in 1696 in these words:

"The suffering was in no wise less than that among the Israelites when they wandered in Egypt on their way to Palestine. One experienced severe hunger, thirst, sickness, cold, continued watching and other work, and beyond all this one tried to understand whence all these sufferings came."

Ships continued to be of unhygienic character, with slight gradual improvement in living conditions until the early part of the last century,

when the introduction of iron in 1818 as a substitute for wood, and the introduction of steam commenced the revolution which has resulted in greater safety, greater comfort, and infinitely greater improvement in living conditions.

Nelson's flagship "Victory" was of 2162 tons displacement.

The first steam ship to cross the Atlantic was the "Savannah" from Savannah to Liverpool in 1819. She was 130 feet long, 1380 tons, and was originally built to sail.

CHAPTER III

DEVELOPMENT OF NAVAL ARCHITECTURE AND ITS INFLUENCE ON NAVAL HYGIENE

The principal changes in naval architecture which must be taken into account in hygiene are:

I. The substitution of steel for wood.

II. The introduction of steam.

FIG. 1.—The United States Sloop-of-war Wasp, a famous war vessel of the Revolution. A wooden ship propelled by sails. (*Courtesy of the Naval Historical Society.*)

III. Division into compartments.

IV. Application of electricity.

V. The development of the submarine vessel.

I. **The Substitution of Steel for Wood.**—The substitution of steel for wood in ship construction has rendered possible the building of vessels of much larger type and greater strength.

The iron and steel vessels can be made water-tight and kept so. Despite careful caulking, the seams of wooden vessels would separate, allow the entrance of sea water, and produce a wet and unsanitary bilge. This water would tend to decompose, as would the wooden surface containing it. Foul odors inevitably resulted. Wood saturated with salt water is difficult to dry thoroughly because of the hygroscopic quality of the salt which is left after evaporation takes place. The absorbent quality of wood prevented its thorough cleaning if soiled by infectious material. Its inflammability made it far more dangerous to life than is the iron structure.

The very dampness between decks on the old wooden ships was held accountable for the high morbidity rate for colds, rheumatic and respiratory diseases.

II. **The Introduction of Steam.**—The introduction of steam has rendered living conditions on board ship incomparably more comfortable than they were in earlier days. Steam has shortened the time between ports, thus enabling the more frequent replenishment of fresh food supply, and also has given to those who "go down to the sea in ships" diversion and variety of scene, which render less intolerable monotonous days and nights aboard ship.

Steam has been a great boon to the sailor man in that through it he obtains distilled water for drinking purposes, and may have fresh water for bathing and laundering his clothes.

On board ship steam renders possible almost complete abolition of water-borne disease. Steam further operates cold storage plants, and enables the keeping of frozen meat for an almost indefinite period.

In January, 1910, when making passage on a merchant vessel from Yokohama, Japan, to Naples, Italy, ice cream was served at the dining table while passing through the Indian Ocean. Inquiry as to the source of the ice cream evoked the following facts:

It had been made by a prominent New York ice cream manufacturer, had been shipped to Bremen, had been carried thence through the Mediterranean Sea, Isthmus of Suez, Red Sea, etc., to Yokohama, Japan, and was being served on the return voyage which was then about half over. This ice cream had been actually on board ship not less

than ten weeks. It was excellent, and no ill effects are known to have followed its ingestion.

Steam has contributed to the comfort of those on board ship through its utilization for heating purposes. No longer must the dirty, dangerous, air-polluting stove be depended upon for its stinted supply of heat in living spaces, and no longer must, as formerly was the case on men-of-war, solid shot be heated and carried from the stove to a sand-box, whence it would radiate its heat and give its poor comfort to the shivering occupants of a room.

FIG. 2.—A superdreadnaught of today. A steel steamship.

Steam operates a large amount of the auxiliary machinery on board ship, and thereby relieves man of much arduous work. It renders possible the sterilization of clothing and bedding in cases of infectious disease aboard ship, and permits the ship's surgeon to do aseptic work.

Steam or its handmaiden, electricity, operates the ventilating fans which carry fresh, respirable air throughout the living spaces, and exhaust the polluted air.

Steam renders possible good light on board ship, and prevents the air pollution formerly incident upon the combustion of candles or oil lamps.

III. **Division into Compartments.**—Division into compartments has modified the effect upon living on board ship advantageously and disadvantageously.

Its principal advantages may be set down as follows:

(*a*) It affords an **easy and practicable method of stowing the load** so as to prevent shifting of cargo in case of heavy weather. The shifting of cargo to one side or the other even may result in capsizing the ship.

(*b*) The **division of ships into water-tight compartments** below the water-line, and the maintenance of integrity of these compartments has **resulted** in the repeated **saving** of **ships** which, had they not been subdivided, would have filled and sunk upon occasion of serious injury to any part of their under-water body. The rush of inflowing water is limited to the compartment injured. This compartment may be flooded, yet the life of the ship is not seriously threatened in most instances. If the ship were a single compartment the same injury would cause her to fill rapidly and go to the bottom.

(*c*) Compartments **limit** to a great extent the **odors, gases and wild heat** which otherwise would pollute the general body of air contained in the ship.

(*d*) They **render possible** the **privacy** of living spaces, and

(*e*) **Enable** the **proper heating** of these spaces without rendering it necessary to heat the entire amount of air contained in the ship.

(*f*) Division into compartments **enables** the **carrying** of **a variety of cargo;** for instance, one compartment may contain fuel oil, another fresh water, and another flour, sugar, or some substance which would be damaged by contact either with water or oil.

(*g*) Manifestly the division into rooms and compartments **tends to limit** the spread of **air-borne disease,** for instance droplet infections.

(*h*) **Limits fire.**—In case of fire the stricken portion of the ship may be immediately cut off from communication with the remainder of the interior, and the fire extinguished more easily.

(*i*) Subdivision **limits** the **effect of flying fragments of a bursting shell.**

The principal disadvantages lie in (*a*) the limitation of the flow of air currents, thus **preventing thorough natural ventilation;** (*b*) in **additional weight of material which limits** correspondingly the **carrying capacity** of the ship; and (*c*) **additional expense.**

IV. **The Application of Electricity.**—Electricity is used on board ship for illuminating purposes, and the heat and air pollution consequent upon the use of candles and lamps is prevented.

In certain of the later ships electric ovens limit the amount of heat which formerly was wasted through burning coal ranges. Also some ships are in part heated with electric heaters. The ship is controlled by systems of signals and telephones and the guns are fired by electricity.

Much of the auxiliary machinery is operated by electricity. The application of this form of energy has shown itself to be valuable in the operation of auxiliary machinery formerly driven by steam, electricity being far less productive of wild heat than would be the operation of the same machinery by steam.

The psychic effect upon passengers and crew of wireless communications should not be forgotten. It is conducive to contentment to receive the latest news from the world during the long voyage, and further than this breaking of the monotony, there is a certain sense of security in feeling that the sending of an "S. O. S." will be answered by a rush of friendly aid brought by distant steamers.

V. **The Development of the Submarine Vessel.**—The development of the submarine vessel appears at present to concern naval forces rather than merchant steamers in the matter of bearing upon health. The submarines offer problems for solution peculiar to themselves which will be a subject of comment elsewhere.

It remained for the Civil War to bring the use of steel to war-ship construction and the development of the submarine.

Ships armored with steel for defensive purposes were not known until the Civil War, when the Confederate ship "Merrimac," a wooden ship, was razeed and her sides covered with railroad iron in order to protect her from gun fire.

It is of historical interest to know that the Confederates also employed small cigar shaped boats, made of boiler iron, hand propelled, and carrying a torpedo on a spar. These small submarines were called "Davids," presumably from the biblical story of David and Goliath. One of these "Davids" sank the Federal ship "Housatonic."

Today we have the palatial passenger steamers which give one "all the comforts of home" except stability, and war-ships have developed correspondingly.

CHAPTER IV

THE SHIP

A ship is a hollow, modified spindle-shaped, sea-going structure of steel, concrete or wood, having quarters for the crew and spaces for passengers, cargo, or both.

Ships are propelled by wind, steam, electricity, or oil engines. They may be classified as:

1. **Merchantmen.**
   - (*a*) Passenger ships;
   - (*b*) Freighters;
   - (*c*) Colliers;
   - (*d*) Tankers;
   - (*e*) Fishermen;
   - (*f*) Tugs.
2. **War Vessels.**
   - (*a*) Superdreadnaughts;
   - (*b*) Dreadnaughts;
   - (*c*) Battleships;
   - (*d*) Cruisers;
   - (*e*) Torpedo boats;
   - (*f*) Torpedo boat destroyers;
   - (*g*) Submarines;
   - (*h*) Submarine chasers;
   - (*i*) Train:
     1. Hospital ships;
     2. Transports;
     3. Colliers;
     4. Tankers;
     5. Supply ships;
     6. Water boats;
     7. Dispatch boats or tenders;
     8. Tugs.

(*j*) Monitors;
(*k*) Mine layers;
(*l*) Mine sweepers.

3. **Seagoing Pleasure Craft.**
(*a*) Steam yachts;
(*b*) Auxiliary yachts;
(*c*) Sail yachts.

Formerly ships were built with a single hull. Within recent years many merchantmen and most men-of-war have been constructed with two hulls. One is nested inside the other, but they are separated from each other by what is known as a double-bottom space. The degree of separation between the two hulls or shells varies, depending upon the plan of the ship, but at some places may be so much as several feet.

This double-bottom space is subdivided into compartments by plates, some of which are longitudinal and some transverse. These compartments at certain points communicate with each other by manhole plates which are water-tight and kept closed except when opened for inspection, airing, or repair.

The central longitudinal plate is known as the keelson, and along it on either side are the bilge spaces. The general drainage system of the ship enters into these spaces, from which the bilge water, as this collection of drainage water is called, can be pumped overboard.

This double-bottom space, divided as it is into numerous compartments, which ordinarily are empty, gives additional buoyancy to the ship, and greatly increases its safety in case of injury to any portion of the outer hull.

Above the water-line the double-bottom or cellular construction does not persist, but a single hull is continued up to the weather deck.

Thus far description has been limited to the hull of the ship. At varying intervals, depending upon the length of the ship, there are water-tight bulkheads which separate completely one water-tight compartment from another throughout the entire width of the ship, and extend in a vertical direction upward considerably above the water-line. These water-tight compartments in certain portions of ships do not communicate with each other below the water-line, and if one compartment were flooded the water would be excluded from the neighboring compartments by the water-tight bulkheads just as effectually as it is excluded by the ship's hull or side. At certain necessary places these water-tight compartments must be perforated in order to enable

the passage of steam pipes, water pipes, drainage pipes, and electric lines. In each of these cases the perforation is made by a water-tight joint, so that in case of the flooding of the compartment water could not enter the next compartment unless the pipes perforating the bulkhead were broken.

At the forward end of the ship the hull is very commonly extended above the water-line higher than elsewhere except at the extreme after-end, and a deck covers over the space included between the hull at the forward-end and the after-end. This portion of the ship at the forward-end is known as the forecastle, and the corresponding upward extension of the hull with its bridging deck at the after-end is known as the poop.

The forward-end of the ship is known as the bow, and the opposite or after-end of the ship is called the stern.

If one stands facing the bow, that side of the ship on the right hand is known as the starboard side, while the side on the left hand is known as the port or larboard. These terms are fixed with reference to the ship just exactly as the terms right hand and left hand are fixed terms with reference to an individual.

Midway between the bow and stern is the region of the ship commonly known as her "waist." The "eyes of the ship" refer to the section of the ship far forward.

"The cabin" is a term commonly applied to the captain's quarters, and on passenger steamers the terms first and second cabin refer respectively to the spaces occupied by first- and second-class passengers.

The wardroom, a term more commonly used on naval vessels, is the space occupied by the senior commissioned officers. The sickbay is the ship's hospital, and on board ship the kitchen is called the galley. The water closet is called the head. Stairs are ladders in nautical parlance, and we speak of "going above" or "below decks" according to whether we are going up or down stairs. The floors on which one walks are called decks, and instead of the ceiling of a room we speak of the deck above. A partition or wall aboard ship is called a "bulkhead."

An opening in the deck by which access may be had to spaces below is called a hatch, and windows on board ship are known as air-ports.

That portion of the ship situated above the weather deck usually is referred to as the superstructure. The bridge is an elevated platform situated forward of the waist, and generally extending entirely across the ship. It is surrounded by a rail to prevent falling from it,

and is the point from which the captain or officer of the deck cons the ship while she is underway. From this bridge extend voice tubes, engine-room indicators, telephones, and all means of interior communication with the various parts of the ship. From the bridge are also sent the signals of various kinds—flags, semaphore, lanterns, rockets, ardois, etc., when necessary.

On men-of-war, as well as on passenger steamers, there is a portion of the weather deck known as the quarterdeck, and this quarterdeck is the place at which the officer of the deck is expected to receive persons going from or coming on board ship on business. The quarterdeck with its traditions is regarded almost with sanctity on board men-of-war. It is here that official ceremonies are conducted and honors are received and rendered when calls are made between naval commanders of the ship's own or other navies.

The quarterdeck space in port corresponds to the office of the officer of the deck, who is expected to stand his watch in this portion of the ship, to receive persons going to and from the ship, and to superintend the receipt and despatch of stores. So soon as persons have transacted business at this point they are expected to clear the quarterdeck at once in order that the officer of the deck may be unhampered in the performance of his duties by having persons crowded around him.

CHAPTER V

AIR

Definition.—Pure air is a colorless, odorless, tasteless, gaseous mixture enveloping the earth.

This air envelope is variously stated to be from 10 to 50 miles in thickness, but the range of man's activities above the earth is comparatively small, only the lower air strata supporting life.

Great discomfort is experienced by many at an altitude of 3000 meters, a distance of less than 2 miles.

At an altitude of 8600 meters, or 4.1 miles, Sivel and Crocé-Spinelli died, while Tissandier, the third member of their party, barely was able to bring to the ground the balloon in which they ascended. The barometric pressure at an altitude of 8600 meters is 262 millimeters, and the oxygen partial pressure is 52.4 millimeters.

Berson and Süring rose to an altitude of 34,500 feet (6.5 miles) in 1901, and became unconscious during the highest portion of their flight, even when using oxygen inhalations.

Flemming and Steyer rose to a height of 8910 meters (29,700 feet, or 5.6 miles) in June 1911, but oxygen poverty of the air was so great as to produce grave symptoms requiring oxygen inhalations to save their lives.

The observatory at El Mirti in the Andes is the highest altitude known to be inhabited continuously by man. It is 5880 meters or 3.7 miles above sea level.

Without oxygen inhalations an altitude of 5 miles is the maximum limit of man's endurance. The naval hygienist must consider this in connection with aerial navigation.

The physical characteristics of air are:

1. Temperature;
2. Mobility;
3. Elasticity;
4. Density or weight;
5. Humidity (in its effect upon man).

Temperature.—The atmospheric temperature upon the earth's surface varies greatly between two or more given points, and often fluctuates widely at the same point, *e.g.*, in parts of Africa a temperature of 50°C. (122°F.) is not uncommon, while in northern Asia −70°C.

(−94°F.) often is observed. Again in certain parts of the world a scorching daily temperature is followed by great chilling or freezing at night.

Rosenau points out that commonly a temperature of 250°F. must be borne by foundrymen, while a temperature of −75°F. must be endured in some inhabited parts of the globe.

From this it is seen that man possesses a wide range of adaptability (325°F.) to temperature variation.

The atmosphere is capable of great heat absorption, the degree varying in different regions and depending upon:

(*a*) Latitude;
(*b*) Altitude;
(*c*) Season;
(*d*) Ocean currents;
(*e*) Proximity to volcanoes or hot springs;
(*f*) Wind;
(*g*) Proximity to man's industrial activities.

Thermometer.—The temperature of the air is best measured by the mercurial thermometer. This should be made after the pattern of the ordinary clinical thermometer, having a long glass bulb filled with

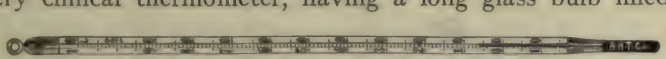


FIG. 3.—A properly made thermometer. The scale is etched on the glass.

mercury at the lower end of, and continuous with, a long glass tube, the end of which is sealed. The cavity of the bulb and the lumen of the tube are continuous.

As with the clinical thermometer the scale should be etched upon the glass, and not placed upon any frame or backing. Erroneous readings readily may result from the slipping up or down of the mercury-containing tube upon such frame or backing, consequently disturbing the correspondence between the figures on the scale and the height of the mercury column.

Three scales are used in grading thermometers, the barometer reading 760 millimeters.

1. The **Fahrenheit** scale which places zero at the temperature obtained by mixing equal parts of sal ammoniac and snow, which mixture produced the lowest known temperature when the scale was adopted in 1714. This temperature was regarded as absolute zero. The temperature of melting ice, or "freezing point," on the Fahrenheit scale is 32°F., while the boiling point is placed at 212°F. The Fahrenheit scale is in common use in the United States, England, and some other countries.

2. The **Centigrade** scale (often called "Celsius" after its inventor) places zero at the "freezing point" (32°F.) and its boiling point is 100°. The temperature range from freezing to boiling distilled water is divided into 100° parts or degrees. This Centigrade scale is in use for nearly all scientific work in the United States and abroad.

3. The **Réaumur** scale places its zero at freezing point (32°F. or 0°C.) and adopts 80 as its boiling point, subdividing the range from freezing point to boiling point into 80 parts or degrees.

From the foregoing it will be seen that:

	Fahrenheit		Centigrade		Réaumur
Boiling point.....	212°F.	=	100°C.	=	80°R.
Freezing point.....	32°F.	=	0°C.	=	0°R.
Therefore.....	180°F.	=	100°F.	=	80°R.
Therefore.....	1°F.	=	$\frac{5}{9}$°C.	=	$\frac{4}{9}$°R.

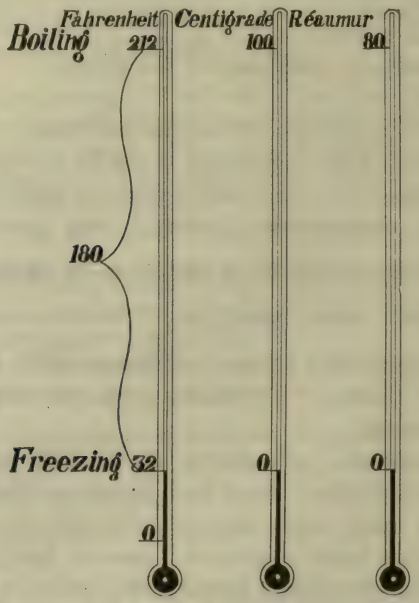


FIG. 4.—A sketch showing the method of graduation of the Fahrenheit, Centigrade and Réaumur thermometers and that 180°F. equals 100°C. and 80°R.

The formula for converting Fahrenheit into Centigrade is C. = (F.− 32°)$\frac{5}{9}$.

e.g., **113°F.** = (113° − 32°)$\frac{5}{9}$, or 81°×$\frac{5}{9}$ = **45°C.**

The formula for converting Centigrade into Fahrenheit is F. = $\frac{9}{5}$°C. + 32°.

e.g., **45°C.** = (45° × $\frac{9}{5}$) + 32,° or 81° + 32° = **113°F.**

Conversions into and from the Réaumur scale may be similarly made.

Lines uniting points of equal temperature on the earth's surface are called *isotherms*.

Physiology.—Effect of hot and cold air upon the body:

Cold air stimulates the body and acts as a tonic, accelerating metabolic change;

Warm air depresses the body, retarding metabolism;

Dry air is tonic and stimulating;

Moist air is depressing.

As temperature and humidity increase, depression increases, and at a wet bulb temperature of 85°F. the body temperature begins to rise owing to diminished heat loss on part of the body, even though it be at rest.

Progressive increase of temperature and humidity will result in heat stroke at a temperature far below that which can be borne readily if the relative humidity be low.

Small is the authority for the statement that man generates enough heat to raise his body to the boiling point (212°F.) in one and one-half days if no body heat is allowed to escape. But for the kindly offices of evaporation, radiation, and conduction we should all be boiling after we are two days old.

The most comfortable temperature for man is from 65°F. to 75°F. At 77°F. the temperature commences to "feel warm" or uncomfortable, hence is called the "*critical temperature.*"

Mobility.—Heated air expands and rises because of its decreased density, cooler, heavier air rushing in to fill the space from which the heated air is rising.

Air currents are thus established. When in nature this process occurs on a large scale wind is produced. Wind is air in motion.

Practically all air currents except those produced as result of man's activities are due to temperature differences. The wind and air currents are of much value to man in influencing the temperature of his environment; removing excessive humidity; bringing to him fresh and carrying away vitiated air.

Elasticity.—As pure air is a mechanical mixture of gases it follows the physical laws governing gases, possesses tension, or elastic force; is compressible and is capable of liquefaction under low temperature (−190°C.) and at atmospheric pressure (760 mm).

Density or Weight.—Air has weight. One hundred cubic inches of dry air weigh 31 grains.

As a man moves at the bottom of the air ocean he sustains the pressure or weight of a column of air extending from the earth's surface to that of the air ocean, and having an area in horizontal section equal to the area of the horizontal section of the man at the same level.

This amount of pressure is about 15 pounds to the square inch of body surface, actually 14.64 pounds, and as the area of body surface of an average size man is about 16 square feet, the pressure sustained by an individual at sea level approximates 16 tons.

The density of air is measured by the barometer.

The Barometer.—If a glass tube about 34 inches long, closed at one end, be filled completely with mercury and inverted in a basin of mercury, the column of mercury within the tube gradually will fall until it reaches a point where it remains stationary, being exactly balanced by a column of air extending from the upper limit of the air ocean to the level of the lower end of the column, and having a cross-sectional area identical with that of the column of mercury.

FIG. 5.—The aneroid barometer.

The height of this column at the sea level is 29.92 inches or 760 millimeters. Depending upon the weight of the air column will be the weight (and of course the height) of the mercury column which it exactly balances.

Such a tube filled with mercury, inverted in a basin of mercury, and having an accurately graduated scale from which the height of the mercury column may be read is called a **Cistern barometer, Mercurial barometer,** or simply **barometer,** and becomes for us a direct measure of weight or density of air, expressed in terms of height of column.

A barometer of this kind is in daily use aboard ships, and at the Weather Bureau's observation stations for use in determining atmospheric pressure.

Heated air becomes lighter and rises, cold air rushes in to take its place. Winds are thus formed. So the barometer, by telling us whether the air is lighter or heavier than normal, gives valuable information as to what weather conditions may be expected.

Another barometer, useful because of its small size and portability, is the **Aneroid** barometer, which consists of a thin-walled metal chamber from which the air has been exhausted and to which is attached an index or pointer registering upon a scale the degree of pressure or "squeeze" exerted by the atmosphere upon this thin-walled vacuum chamber.

The scale is graduated by comparison with the standard mercurial barometer, both being simultaneously placed under the receiver of an air pump and subjected to various pressures.

Following Boyle's law the temperature of a given volume of air remaining the same, the volume will vary inversely with pressure it bears.

E.g., the temperature remaining the same:

1000 c.c. of air equals 900 c.c. at 33.24 inches (mercurial barometer)
1000 c.c. at 29.92 inches (mercurial barometer)
1100 c.c. at 27.02 inches (mercurial barometer)

For purposes of accurate estimation in volumetric work with air all specimens are considered under the pressure at sea level or are converted to that pressure, which is the standard. In each of the preceding examples the volumes 900 c.c. and 1100 c.c. would be reduced to standard. The importance of these variations of atmospheric pressure is emphasized when it is remembered that:

(*a*) **Mountain sickness,** and no doubt certain accidents to aviators, are due to rarefaction of atmosphere as result of altitude;

(*b*) **Caisson Disease.**—"Bends," and diver's palsy are conditions resulting from exposure to excessive air pressure with too rapid decompression; and,

(*c*) **Squeeze** may cause death of a diver as result of inadequate pressure of air delivered within the diving suit.

Lines uniting points of equal pressure on the earth's surface are called *isobars.*

Humidity.—Moist air is lighter than dry air, hence moist air tends to rise above dry air of the same temperature. This physical property of air results in air currents which remove heat and humidity from man.

Humidity will be further discussed under "Chemical Composition of Air."

Chemical Composition

Air is a mechanical mixture of gases, not a chemical compound. The chemical composition of air is given by Rosenau as:

Oxygen	20.94 per cent. by volume
Nitrogen	78.09 per cent. by volume
Carbon dioxide	0.03 per cent. by volume
Argon	0.94 per cent. by volume
Helium	Trace
Krypton	Trace
Neon	Trace
Xenon	Trace
Hydrogen	Trace
Peroxide of hydrogen	Trace

Ammonium	Trace
Ozone	Trace

Gatewood says **sea air** contains:

Nitrogen (argon, etc.)	77.90600
Oxygen (ozone)	20.65955
Water vapor, as gas	1.40000
Carbon dioxide	0.03360
Ammonia	0.00080
Nitric acid	0.00005

The average percentage of water vapor in sea air is 1.4 per cent.

From a hygienic viewpoint we may consider the components of air as:

A. Essential;

B. Non-essential.

A. The **essential constituents** are those necessary to man's welfare, yet the percentage concentration of these constituents may vary to an extent sufficient to be harmful or even fatal to man.

The **essential components** are:

1. Oxygen;
2. Nitrogen;
3. Carbon dioxide;
4. Aqueous vapor.

1. **Oxygen.**—Oxygen is a gaseous element necessary to all known life. Even anaerobic bacteria, while developing better under exclusion of atmospheric air, consume oxygen, obtained through cleavage of carbohydrates in their nutrient media.

Man must have oxygen constantly. It constitutes 20 per cent. of atmospheric air and reduction below 16 per cent. gives distress, below 12 per cent. slow death, and complete deprivation of oxygen for five minutes results fatally to man.

The oxygen percentage of the atmosphere must vary within very narrow limits in order to maintain life and healthy physiological processes.

Oxygen exists in the air under a partial pressure of 152 millimeters of mercury and under this partial pressure enters the lungs, unites with the hæmoglobin of the blood to form a readily dissoluble or unstable compound—oxyhæmoglobin. Oxygen is supplied to the tissues by the

breaking down of the oxyhæmoglobin, and ultimately is discharged from lungs as carbon dioxide.

	O	N	CO_2	HO_2
Inspired air contains....	20.96	79	0.03	X
Expired air contains....	16.02	79	4.38	100
	4.94	0	4.35	100

It will be seen that of each cubic foot of air inhaled the system appropriates 4.94 per cent. of O and excretes 4.35 per cent. CO_2. The excess of oxygen, 0.59 per cent. by volume, most probably is excreted as water by lungs, skin, or kidney, probably the former.

2. **Nitrogen.**—Nitrogen belongs to the indifferent gases. Examination of expired air shows no diminution of the volume of nitrogen inspired.

The circulating blood shows only 1.7 per cent. of nitrogen in solution. This percentage appears constant both in arterial and venous blood and suggests that the nitrogen in the blood probably is not of respiratory origin.

The sole function of nitrogen in the atmosphere appears to be that of a diluent preventing the untoward effects which would result from too great concentration of oxygen.

Nitrogen, however, is largely used in the growth of plants, which may be regarded as the source of all nitrogenous foods used by man, both animal and vegetable.

In the growth of plants the so-called nitrifying bacteria play an important rôle, forming nodes upon the roots of certain legumes and other plants used for food by man or by animals which supply milk and meat to man. These nodes aid the plant in absorbing necessary nitrogen.

3. **Carbon Dioxide.**—The normal percentage of carbon dioxide in air is 0.03 per cent. by volume. Carbon dioxide is constantly present in all atmospheric air and is necessary to the growth of vegetable life.

4. **Aqueous Vapor.**—The atmosphere contains water vapor in amount varying from zero to saturation (100 per cent.) for a given temperature and pressure.

Absolute moisture is that actually present in a volume of air.

Saturation is that condition of a volume of air when it contains the maximum possible quantity of water vapor.

Saturation deficit is the weight of water vapor required to saturate a given volume of air minus absolute moisture.

The amount of water vapor in a given volume of air is expressed as a percentage of the amount that the volume of air could hold at its temperature.

This percentile expression of the hygrometric state, or approximation to saturation with water vapor, of a given volume of air at its temperature is the "relative humidity" of that air.

Relative humidity, then, is a term expressing the percentage of saturation with water vapor for its temperature of a given volume of air.

In other words:

$$\text{Relative humidity} = \frac{\text{Weight of aqueous vapor actually present} \times 100}{\text{Weight of aqueous vapor it could contain}}$$

E.g., the weight of aqueous vapor in a cubic foot of air at 75°F. is 9.39 grains when the air is saturated for its temperature. A cubic foot of air at the same temperature, 75°F., and containing 4.695 grains of vapor would have a relative humidity of $\frac{4.695 \times 100}{9.39} = 50$ per cent. R. H.

Aqueous vapor which at 70°F. would condense into fog, snow or rain would at 90°F. show a clear sky.

The amount of water vapor in the atmosphere is determined by means of hygrometers, which may be:

(*a*) Chemical hygrometers;
(*b*) Condensing hygrometers;
(*c*) Hair hygrometers;
(*d*) Psychrometers.

(*a*) The **chemical hygrometer** is an apparatus which enables the passing of a known volume of air through a definite weight of an hygroscopic salt. Increase in weight of the salt measures the weight of water vapor present in the volume of air from which the moisture has been extracted.

(*b*) The **condensing hygrometer** is an apparatus by which are determined the temperatures at which moisture is deposited upon and absorbed from a metal surface by the raising and lowering of atmospheric temperature. The average of the temperatures at which moisture is deposited, and that at which it disappears as the temperature is raised is known as the "dew point."

(*c*) The **hair hygrometer** is one of the most delicate of instruments and depends upon the expansion of a strand of human hair as result of absorption of moisture and its contraction upon drying. The degree of tension resulting from the expansion or contraction is indicated by a pointer upon a standardized scale. Some of these instruments, *e.g.*, the hygrophant, are ingenious and very convenient for use in determining temperature, relative humidity, etc.

(*d*) The **psychrometer,** or wet bulb thermometer, is the hygrometer used in the United States Navy.

Two mercurial thermometers, one of which has its bulb covered by a thin cotton wick which extends into a small cup of distilled water, constitute the essential features of this instrument.

The bulb is kept constantly wet by means of the wick which draws water by capillary attraction from the cup. Evaporation from the wick covering the wet

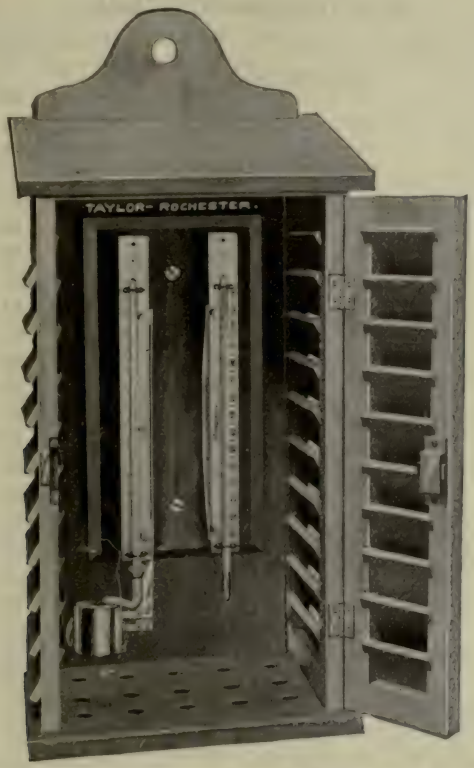


FIG. 6.—The psychrometer commonly used on board ship for determining the degree of humidity in the atmosphere.

bulb reduces the temperature of the mercury in the bulb, consequently, unless the atmosphere is very near to saturation there will always be considerable difference between the dry bulb thermometer and the wet, the latter being the lower. This difference of readings indicates the condition of atmospheric humidity. If the wet bulb is as high as the dry it is evident that the atmosphere is saturated and that as the vapor is already at maximum tension, no evaporation from the surface of the wet bulb can take place, and the wet and dry bulb thermometers register alike.

If the air be very dry or thirsty, evaporation from the wet bulb will be rapid, cooling of the bulb will take place, and the wet bulb thermometer may register several degrees below the dry bulb. The difference between the dry and wet bulb thermometers indicates the degree of tension of the aqueous vapor in the air.

Humidity tables accompany the instrument and from them one may ascertain the percentage of saturation (relative humidity) for the temperature registered by the dry bulb.

RELATIVE HUMIDITY TABLE.

TABLE OF R. H. COMPUTED FROM D. B.—W. B. OF STATIONARY PSYCHROMETER.

Temp. dry bulb	Difference between dry and wet bulb														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fahr.	Relative humidity at saturation = 100														
90	95	90	85	81	77	73	69	65	62	59	56	53	50	47	44
89	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
88	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
87	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
86	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
85	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
84	95	90	85	80	76	72	68	64	60	57	54	51	48	45	43
83	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
82	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
81	95	90	85	80	76	72	68	64	60	56	53	50	47	44	41
80	95	90	85	80	75	71	67	63	59	56	53	50	47	44	41
79	95	90	85	80	75	71	67	63	59	56	53	50	47	44	41
78	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
77	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
76	94	89	84	79	75	71	67	63	59	55	52	49	46	43	40
75	94	89	84	79	74	70	66	62	58	55	52	49	46	43	40
74	94	89	84	79	74	70	66	62	58	55	52	48	45	43	40
73	94	89	84	79	74	70	66	62	58	54	51	48	45	42	40
72	94	89	84	79	74	69	65	61	57	54	51	48	45	42	39
71	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
70	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
69	94	88	83	78	73	68	64	60	56	53	50	47	44	41	38
68	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
67	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
66	94	88	83	78	73	68	64	60	56	52	48	45	42	40	37
65	94	88	83	78	73	68	63	59	55	51	48	45	42	39	36
64	94	88	82	77	72	67	63	59	55	51	48	45	42	39	36
63	94	88	82	77	72	67	63	59	55	51	47	44	41	38	35
62	94	88	82	77	72	67	62	58	54	50	47	44	41	38	35
61	94	88	82	77	72	67	62	58	54	50	47	44	41	38	35

RELATIVE HUMIDITY TABLE.—Continued.

TABLE OF R. H. COMPUTED FROM D. B.—W. B. OF STATIONARY PSYCHROMETER.

Temp. dry bulb	Difference between dry and wet bulb														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fahr.	Relative humidity at saturation = 100														
60	94	88	82	76	71	66	62	58	54	50	46	43	40	37	34
59	94	88	82	76	71	66	61	57	53	49	46	43	40	37	34
58	93	87	81	76	71	66	61	57	53	49	46	43	40	37	34
57	93	87	81	75	70	65	61	57	53	49	45	42	39	36	33
56	93	87	81	75	70	65	60	56	52	48	44	41	38	35	32
55	93	87	81	75	70	65	60	56	52	48	44	41	38	35	32
54	93	86	80	74	69	64	59	55	51	47	43	40	37	34	31
53	93	86	80	74	69	64	59	55	51	47	43	39	36	33	30
52	93	86	80	74	69	64	59	54	50	46	42	39	36	33	30
51	93	86	80	74	68	63	58	54	50	46	42	38	35	32	29
50	93	86	80	74	68	63	58	54	49	45	41	37	34	31	29
49	93	86	79	73	67	62	57	53	49	45	41	37	34	31	28
48	93	86	79	73	67	62	57	52	48	44	40	36	33	30	..
47	93	86	79	73	67	61	56	51	47	43	39	36	33	30	..
46	93	86	79	73	67	61	56	51	47	43	39	35	32	29	..
45	92	85	78	72	66	60	55	50	46	42	38	34	31	28	..
44	92	84	78	71	65	59	54	49	45	41	37	34	31	28	..
43	92	84	78	71	65	59	54	49	45	41	37	34	31	28	..
42	92	84	78	71	64	58	54	49	44	40	36	33	30	27	..
41	92	84	77	70	64	58	53	48	43	39	35	31	28	..	..
40	92	84	77	69	63	57	52	47	42	38	34	31	..	..	..
39	92	84	77	69	63	57	51	46	42	38	34	..	..	..	..
38	91	83	75	68	62	56	50	45	41	37	..	..	..	..	..
37	91	83	75	68	61	55	49	44	39	..	..	..	..	..	..
36	91	82	74	66	59	53	47	42	..	..	..	..	..	..	..
35	90	80	72	..	..	..	..	..	..	..	..	..	..	..	..
34	89	79	72	..	..	..	..	..	..	..	..	..	..	..	..
33	89	78	70	..	..	..	..	..	..	..	..	..	..	..	..
32	87	75	..	..	..	..	..	..	..	..	..	..	..	..	..

The **sling psychrometer** is an instrument similar to the psychrometer just described except that it has a strong handle to which is attached the part which moves and carries the thermometer.

By appropriate motion the moving member whirls around the handle, causing more rapid evaporation from the wet bulb thermometer, and in a few moments the readings may be taken, *i.e.*, just so soon as the mercury in each thermometer takes its stand, no longer rising or falling.

This instrument is convenient because of its portability and easy use. The

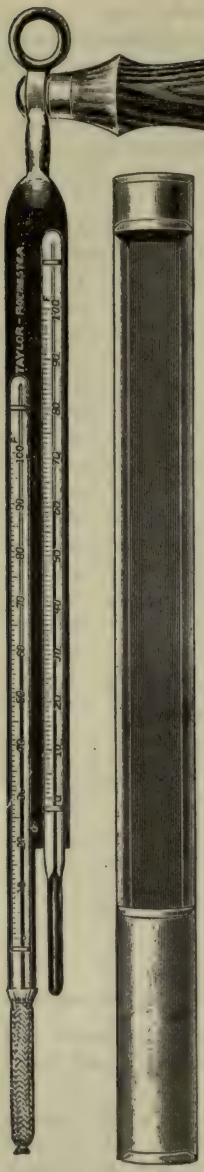


FIG. 7.—A sling psychrometer. (*From Gatewood.*)

above-mentioned humidity tables are necessary to determination of relative humidity by means of this instrument.

At sea the relative humidity of the air is greater than ashore. This depends upon several factors, chief among which are temperature, latitude, and winds.

The chief sources of aqueous vapor in the atmosphere are:

(*a*) Evaporation of water from the earth's surface;

(*b*) Evaporation from the leaves of plants;

(*c*) Evaporation from skins and exhalation from lungs of man and animals;

(*d*) Combustion;

(*e*) At sea, action of winds and waves.

(*a*) The **action of the sun upon** the oceans, rivers, and all **water** on the earth's surface causes a degree of evaporation proportionate to temperature.

(*b*) Enormous amounts of water vapor are given off **from the leaves of growing plants.** Hellriegel estimated that for each pound of dry vegetable matter 325 pounds of aqueous vapor have been discharged into the air.

(*c*) **From Skin and Lungs of Man and Animals.**—Foster estimates that an adult man gives off about 4 pounds of water daily from skin and lungs. Gatewood (Naval Hygiene, p. 192) states that a crew of 800 men at rest would be excreting 1600 pounds of water from the skin in twenty-four hours. This same crew would be exhaling from the lungs at least 500 pounds of water daily (Pettenkofer and Voit estimate 10 ounces of water daily from lungs of adult). Consequently a crew of 800 men would be ex-

creting at least 2100 pounds per day of water as aqueous vapor from skin and lungs.

(*d*) **Combustion** results in formation of considerable water vapor, especially in the vicinage of cities where industrial activities contribute no small amount.

(*e*) **Wind and waves at sea** tend to **throw** much **water vapor,** and fine globules of water in suspension as well, **into the air,** thus rendering the air very moist at sea and for some distance inland.

B. The **non-essential constituents** and pollutions of the air are many and are:

1. Gaseous;
2. Particulate.

1. The gaseous non-essential constituents are:

(*a*) Non-poisonous;

(*b*) Poisonous.

(*a*) The *principal non-poisonous gases* are:

1. Ozone;
2. Peroxide of hydrogen;
3. Argon;
4. Neon;
5. Xenon;
6. Krypton;
7. Coronium and helium.

Ozone and **peroxide of hydrogen** are of more or less accidental occurrence in the air and are believed to be chiefly the result of electrical discharge in the atmosphere. These two gases possess such great oxidizing power that they soon spend themselves in oxidation of organic matter in the atmosphere, consequently they exist in a free state but a very short time.

One part of ozone per million in the atmosphere is irritating to the mucous membranes (Hill and Flack), while 15 parts per million is very dangerous to life if inhaled for a period of two hours. Hence the expression "breathing the pure ozone" is misleading, for "the pure ozone" is really a poison.

Argon, helium, neon, krypton, xenon, and coronium occur in minute quantities in the atmosphere, are usually included in the nitrogen percentage of atmosphere, and are inert scientific curiosities from the viewpoint of the hygienist.

(*b*) The *principal poisonous gases* found in the air are:

1. Carbon dioxide (CO_2);
2. Carbon monoxide (CO);
3. Ammonia (NH_3);
4. The nitrogen gases.

1. **Carbon dioxide** is one of man's excretions. He cannot utilize it. Since man inhales 0.03 per cent. by volume at each inhalation and exhales 4.38 per cent. at each exhalation, more than one hundred times as much, it would appear that the normal CO_2 constituent of air is negligible in its effect upon man.

Carbon dioxide reaches the air from:

(*a*) Vital processes of plants;

(*b*) Expired air from man and animals;

(*c*) Fermentation processes in nature;

(*d*) Chemical changes in nature;

(*e*) Combustion and industrial activity;

(*f*) Charged mineral springs and probably from combustion in the earth's interior.

In an atmosphere containing 4 per cent. by volume of carbon dioxide, *i.e.*, in concentration about equivalent to that of expired air, discomfort soon commences to be felt *if the oxygen* percentage has been correspondingly reduced and considerable irritation of the respiratory center is evidenced.

When the concentration of carbon dioxide reaches 10 per cent. the pulse and respiration are greatly accelerated and consciousness begins to fail.

Experimental animals can live in CO_2 concentration of 25 per cent. if the oxygen percentage be increased to 30 or 40 per cent.

It will be observed that there is a wide range of percentile concentration of CO_2 in air (0.03 to 4 per cent.) which man may bear without discomfort.

As air normally contains 0.03 per cent. by volume of CO_2, excess of this amount must be regarded as further pollution due to respiration, combustion, etc. It appears to be the consensus of opinion of investigators that when the concentration of CO_2 has reached 0.06 to 0.07 per cent. in occupied spaces, the increased temperature, humidity, emanations from skins, clothing, respiratory tract and alimentary canal, will have so vitiated the air that it may be breathed no longer without deleterious effect, despite the fact that the CO_2 percentage is very

small when compared with the concentration of the gas which man comfortably may breathe without harm.

Temporarily he may withstand a much higher concentration, *e.g.*, men in breweries often work in an atmosphere containing 10 per cent. CO_2 to 25 per cent. CO_2.

There is seldom sufficient CO_2 in the air to produce effect dangerous to life, for the air of inhabited spaces becomes intolerable long before even an uncomfortable concentration of CO_2 is present. Prolonged exposure to high concentration of this gas may result in a lowering of vitality.

Estimation of the percentage volume of CO_2 serves as a guide or index to tell us that the air has become noxious, *not because of the concentration of CO_2, but from other causes accompanying the CO_2.*

Formerly CO_2 was regarded as the cause of the "closeness" and unpleasant odor in occupied rooms, and its estimation was considered extremely important.

More recent investigation shows undue significance has been given to the CO_2 content of the air, and hygienists feel that an estimation of CO_2 in air is relatively unimportant and of scant value except as an index to the degree of other pollutions in expired air.

2. Carbon Monoxide.—This is a dangerous and powerful, odorless, colorless, tasteless gas often found in inhabited places and is commonly due to imperfect combustion of coal gas.

In a recent study of the conditions under which some of the cloak, suit, dress, and waist makers work in New York City, the United States Public Health Service found the air in 11.8 per cent. of the shops examined showed an excessive carbon monoxide content. The condition was attributed principally to defective irons used for pressing, or to defective rubber tubes. Red-hot iron possesses the power of absorbing carbon monoxide and giving it off to the surrounding atmosphere.

Kerosene lamps and leaky gas pipes supply their share of this gas to the air. Cold objects when thrust into a coal-gas flame cause incomplete combustion of the gas and CO is formed.

Gréhant says one gram of burning tobacco gives off 82 c.c. of CO. This may explain, in part, the ill-feeling experienced by persons who have spent several hours in air vitiated by burned tobacco.

Imperfect combustion in gasolene engines may cause generation of CO to a dangerous degree in improperly ventilated spaces. Poisoning from this cause has been reported often enough to warrant unusual precautions in ventilating garages and motor boats.

Carbon monoxide in the air in proportion of 0.25 per cent. by volume will cause poisoning and 1 per cent. proves rapidly fatal to animals. A death due to carbon monoxide poisoning occurred recently in the radio room of one of our destroyers. The gas had been generated by a charcoal brazier used for heating the confined space, and the operator was overcome before its presence was known.

3. **Ammonia.**—Ammonia is a constant component of air, usually found in traces, but often in considerable concentration as result of decomposition of nitrogenous organic matter.

4. **Nitrogen Gases.**—The nitrogen gases N_2O_3 and N_2O_5 are found in small quantity in the air as result of action of ozone upon decomposing nitrogenous substances and also as result of direct chemical union of N and O in the atmosphere following electrical discharge.

Sewer Gas.—Because of its disagreeable odor, sewer gas long has been regarded as productive of disease in some vague manner. As a matter of fact workers in sewers appear to have no greater morbidity or mortality percentage than men of their class in other kinds of employment.

It seems probable that vermin (rats, insects, etc.), from sewers constitute a far greater menace to man than sewer air which long has been heartily condemned.

Infectious material flowing in a well-aired sewer is apt to be conveyed to man only by contact, through activities of rats and insects. It is highly improbable that the air has much to do with spread of disease from sewers.

Other gaseous impurities, *e.g.*, H_2SO_2, H_2SO_3, C_2S_3, etc., resulting from industrial activities are found in the air, and in certain localities their concentration is so great as to blast vegetation, and prove dangerous to persons in the vicinage.

Kenotoxin or Anthropotoxin.—For years some have held that there is a specific protein, probably volatile, poison in respired air which is responsible for the lassitude, fatigue, and discomfort felt in crowded spaces, and isolation of such hypothetical poison has been attempted invariably with negative results.

It has been shown conclusively that increased temperature and increased humidity are the essential factors in producing this discomfort, and that mere agitation of the same air will render comfortable the previously close room.

The work on this subject of Pflugge of Breslau has attracted

much attention and has authoritative confirmation. He made a series of observations upon sick, well, young, old, clean and unclean persons in air-tight glass cabinets, under varying conditions of temperature, pressure and relative humidity.

It was found that these persons when subjected to temperature 55°F., relative humidity 66, and CO_2 115 parts per 10000, after three hours and five minutes suffered no ill effects, but showed discomfort with temperature of 80°F., and moderate humidity; while with temperature of 70°F. and high relative humidity all exhibited signs of distress.

This distress was relieved by starting a fan, not by admission of fresh air, not by reducing the temperature in the cabinet, not by reducing the relative humidity, *but merely by starting a fan.* The fan agitated the air and caused increased evaporation from body surface, giving additional comfort because of the cooling effect of the air currents set up by the fan.

In other words, when the temperature and relative humidity were so high as to prevent radiation of heat constantly produced by the body, nausea and distress were felt, although in the lower temperature and relative humidity the subject breathed regularly without ill effect, nearly twice as much CO_2 as has been regarded safe (nearly 400 times the amount of CO_2 contained normally in the atmosphere).

Pflugge found that with their bodies within air-tight cabinets, under high temperature and relative humidity, but breathing fresh air great distress still was felt by the subjects. Surely here the CO_2 could not be charged with producing the severe constitutional symptoms exhibited.

Reversing the process he placed the bodies outside the cabinet, but caused the subjects to breathe CO_2 130 parts per 10,000 (1.3 per cent.) and no deleterious symptoms were observed. Lastly he experimented upon children and adults, subjects of nephritis, heart disease, bronchitis, and anæmia, in his cabinets with CO_2 at 150 parts per 10,000 (1.5 per cent.), temperature 70°F. and relative humidity not over 50. No evil effects were shown but they promptly appeared when the temperature was raised to 80° and the relative humidity was increased, discomfort being proportionate to the increases in temperature and relative humidity, the CO_2 percentage remaining constant.

The experiments of Hill, Rowland and Walker are of interest. An air-tight chamber of 2 cubic meters capacity, containing an electric fan, but having no ven-

tilation, was used as a test cabinet. Occupation of the cabinet resulted in a dry bulb temperature of 87°F., wet bulb 83°F., a CO_2 concentration of 5.25 per cent. and a reduction of oxygen to 15.1 per cent. in forty-four minutes. Under these conditions great discomfort was felt, immediate relief was obtained by starting the fan and occupants of the cabinet cried out for the fan when it was stopped.

Another interesting experiment by the same observers is worthy of attention. Two men, subject and observer, were placed in the cabinet, which was heated by an electric heater and the air humidified until the wet-bulb thermometer registered 85°F. The subject inhaled through a soda-lime mixture and exhaled through an air meter so that only traces of CO_2 could be inhaled. Even thus the subject's temperature and pulse rose although he was not even breathing the small amount (0.03 per cent.) of CO_2 normally contained in the air. When the fan was started his discomfort ceased, and pulse rate fell.

Secretly CO_2 was admitted to the chamber until a concentration of 2 per cent was reached. This was not noticed by the subject. His discomfort was due to increased temperature and humidity within the cabinet, which was relieved by the starting the fan, while the concentration of CO_2 was unnoticed!

It appears that stoppage of heat radiation as result of high temperature and relative humidity is more dangerous to man than any probable pollution by CO_2.

Recent research has resulted in a radical change of opinion concerning the importance of the rôle of CO_2 in respired air, and it seems that:

1. One hundred parts per 10,000 (1 per cent. CO_2) is harmless;
2. Agitation of air in confined spaces is very important;
3. Reduction of temperature and relative humidity usually will reduce discomfort of persons in closed spaces even though CO_2 be above 1 per cent.

Benedict and Milner have shown that if temperature and relative humidity are comfortable the CO_2 content of air practically may be disregarded.

It is "erroneous and unscientific to rely upon determination of CO_2 in air of a room as a measure of its condition for respiration."

If chemical methods are to be depended upon, is it not more rational to determine an oxygen minimum instead of a CO_2 maximum as our gauge of respirability of a given volume of air?

Other gaseous impurities occur in air as result of man's activities, animal life, chemical decompositions, and bacterial action. These are usually unimportant and too numerous to mention.

Particulate Bodies

Particulate bodies are:

1. Inorganic:
   (*a*) From the earth's surface;
   (*b*) From meteoric dust;
   (*c*) From activities of man and animals.
2. Organic:
   (*a*) Dead;
   (*b*) Living.

1. **Inorganic particulate matter** of almost any kind may be swept (*a*) from the earth's surface into the air. Weathering of earth's surface, chemical action and combustion supplemented by man's activities are potent factors of dust production.

(*b*) *Meteoric dust* may be present in the air.

(*c*) If the inorganic *dust* resulting *from industrial activities* be poisonous, acute or chronic specific poisoning may occur, as in lead poisoning, arsenic poisoning, etc.

If the inhaled dust be not an active poison the result is a chronic irritation of the respiratory tract which may go on to pneumonia, as seen in miners, stone-cutters, glass polishers, cutters of precious stones, etc.

Dust is important to man in that its suspension in the air causes diffusion of sunlight, prevents shadows, etc., and the dust particles form nuclei for formation of fog and rain.

2. **Organic particulate matter** (living pathogenic germs) adhering to inorganic dust may produce the specific diseases caused by those germs. Organic particulate matter may be:

(*a*) Dead, or

(*b*) Living.

(*a*) *Dead.*—Under this class may be placed detached particles from plants and the animal kingdom, including man, also minute plants and animals no longer possessing life.

Hair, epithelial cells, and extinct microörganisms are examples of this class.

(*b*) *Living.*—In this extremely important class fall the pathogenic and non-pathogenic bacteria, pollen, insects, and such microörganismal animal life as may be swept up from the earth's surface by air currents or sprayed into the air as minute globules of sputum, excreta, sewage, etc. It is apparent that air pollution with dust or particulate

bodies is apt to occur near factories and that the variety of such pollution and diversity of effect is too great for our consideration here.

Bacteriology.—Experiments have shown that at an elevation of 6300 feet, the atmosphere is free of bacterial life. Fisher has shown that sea air 120 miles from land is sterile. The air of cities contains thousands of bacteria per cubic centimeter, while that of the country seldom contains 100 organisms per cubic centimeter.

In suburban districts the outdoor air contains from fifty to one hundred bacteria per cubic foot which will develop at 20°C., while only about half the number would develop at 37°C.

Mouth streptococci appear to be about twice so numerous indoors (20 to 40 per 100 cubic feet) as in outdoor air in suburban districts. Air plays a far less important rôle in the spread of transmissible disease than originally was attributed to it.

The microscope has proved the air to be innocent of spreading certain dread diseases formerly considered air-borne, and under the searchlight of modern scientific investigation scrupulous disinfection of excreta, linen, dishes, cups, forks, spoons, bath water—indeed everything that comes in actual contact with the patient—has stripped the bogey "air-borne disease" of most of its horror, and caused necessity for terminal disinfection, to appear unnecessary except as source of comfort to the layman who has been accustomed to the inconvenience of fumigation.

Rosenau says "the communicable diseases are not conveyed in the air from ward to ward or even from bed to bed in well-managed hospitals."

Bacillus prodigiosus has been found by Hutchinson to be transported by sputum droplets for a distance of 2000 feet when the temperature is not sufficiently high to dry rapidly the droplets and kill the organisms.

Chaussé (Nouvelles Recherches sur la Contagion de la Tuberculose par l'Air Expiré pendant la Toux, Annales Institute Pasteur Vol. xxx, No. 11, p. 612) and Catheryn V. Riley ("Observations in Baltimore," John Hopkins University, 1915) have given us very recent studies concerning the presence in air of living and possible pathogenic organisms.

The work of Chaussé gives very striking demonstration of readiness with which droplet infection may occur.

While air *per se* seldom contains gaseous pollution sufficient to cause disease, it may carry in suspension dust (glass cutting, etc.), microörganisms (droplets in tuberculosis, etc.), insects (mosquitoes, etc.) which cause disease in man.

CHAPTER VI

AIR ABOARD SHIP

Ships at sea a distance of 100 miles from the shore are in an atmosphere which is practically dust-free and free of bacteria, *i.e.*, they are in an atmosphere of exceptional purity, and unpolluted except by ships themselves.

In ports the ships, of course, have the same air as the locality in which they lie and this may be even offensive. When ships lie in dry docks—especially in warm weather—and the animal and vegetable material scraped from the hull decomposes, or when ships lie in proximity to sewers or manufacturing plants, the air may be disagreeable, and when near certain industrial plants may be dangerous. At sea pure air enters the ship, but it is modified there and polluted according to existing conditions.

The pollutions of air aboard ship are:

1. Gaseous;
2. Particulate.

1. The Principal Gaseous Pollutions

The principal gaseous pollutions are:

(*a*) Gases from respiration and combustion;
(*b*) Aqueous vapor;
(*c*) Gases from stored powder;
(*d*) Gases from gun fire;
(*e*) Gases from stored coal;
(*f*) Gases from gasolene and cleaning and polishing materials;
(*g*) Gases from decomposition:
    1. Bilges;
    2. Torpedo drainage tanks;
    3. Food stuffs;
    4. Water;
(*h*) Gases from turpentine and paint;

(*i*) Gases from water closets, latrines, and scuppers;

(*j*) Gases from storage batteries;

(*k*) Intestinal gases.

Air exchange through walls of buildings on shore is a well-recognized fact.

No transpiration occurs through the sides of a modern ship. Air exchange may occur through hatches, air ports, voice tubes, ammunition hoists, elevator shafts, but otherwise we must regard a steel ship as an air-tight, water-tight vessel, in which men are exhaling daily large quantities of CO_2 and water vapor.

The crew live as if at the bottom of a bottle through the mouth of which the air supply must come and all foul air be removed.

(*a*) The **carbon dioxide** comes principally **from respiration and combustion** of fuel for generation of power. Electric lighting results in no pollution of air from the necessary illumination of the ship. Formerly the use of candles, oil lamps, etc., resulted in great vitiation of the air on board ship.

(*b*) **Aqueous vapor** comes from:

1. *Respiration and perspiration* of the crew (this would amount to more than a ton of water daily in case of a crew numbering eight hundred);

2. *Escaping steam;*

3. *The washing of clothing*, persons, dishes, bulkheads (walls), and decks;

4. *Cooking;*

5. *Evaporation from decks* wet by reason of shipping seas (waves coming on board) in heavy weather; and last, but not least—

6. The relative *humidity of the air* in which the ship is lying.

(*c*) **Gases from stored powder** are quite noticeable at times in the vicinage of magazines, and are suggestive of sulphuric ether. The formula depends upon the composition of the explosive.

(*d*) **Gases** resulting **from great gun fire** are very irritating to the conjunctiva and respiratory mucosa. Obviously the composition of the explosive determines the quality of the gases resulting from detonation, but carbon monoxide and nitrogen gases are the principal poisonous gases. Carbon dioxide also is formed.

(*e*) In the coal bunkers freshly stored coal is more apt to result in gas production than in older coal. Methane especially emanates **from** freshly **stored coal,** while older coal gives off a gas mixture in

which CO_2 is predominant. Finely pulverized coal may absorb up to three times its volume of oxygen, consequently great diminution of oxygen content may occur in the air of a coal bunker. The air in coal bunkers may prove injurious to health:

1. Through *generation of noxious gases;*
2. Through *decrease of oxygen* in contained air;
3. Through *increase of CO_2 tension.*

(*f*) **Gasolene,** now used much for propulsion of motor boats, driving auxiliary machinery, as components of cleaning mixtures, insecticides, and in gasolene torches used by painters, may vitiate the air materially as well as endanger life by explosion and fire. The careless smoker may ignite the fumes with serious result. The "*gasolene jag*" resulting from inhalation of fumes of unburned gasolene resembles the stage of excitement of acute alcoholism, muscular incoördination being less marked.

Inhalation of the fumes resulting from combustion of gasolene gives a graver picture, probably due chiefly to the carbon monoxide constituent of the exhaust gas.

(*g*) **Decomposition of food stuffs;** vegetables, meat, eggs, milk products, etc., in the galleys, butcher-shops, store-rooms, and cold storage may result in offensive gases.

The odor of *oil decomposing* in the moist, hot engine rooms, and bilges may become very disagreeable, especially to those who are seasick.

The *decomposition occurring in water* which has been used for bathing purposes and has been secreted in a bucket for future use and perhaps forgotten, or else poured into a drain leading to a bilge or compartment infrequently pumped out, may be a source of discomfort by reason of its foul-smelling odor.

The *torpedo drainage tank*—a tank receiving the drainage from the torpedo room—is especially apt to be a nuisance in this sense. Men living most of their time below decks in the torpedo room frequently have an unauthorized supply of water for washing purposes in buckets at their stations—despite the fact that this is forbidden—for it is some distance from the torpedo room to the wash room. After using this water it is emptied into the drains leading into the torpedo drainage tank. Here decomposition occurs and unless special attention is paid to the frequent, regular pumping out and cleaning of the tank, its content of wash water, oil, etc., will become most foul. Needless

to say the above-mentioned disposition of bath water is prohibited. The hoarding of fresh water by the sailorman is a relic of the days when he had too small allowance of fresh water. In our navy today his allowance of fresh water is practically unlimited. The surreptitious emptying of waste water into unauthorized places is properly punished when the offender is detected.

The air also may be vitiated by the *emanations from sweaty clothing* and *from* drainage pipes leading from the *firemen's wash room.*

(*h*) The **odors arising from turpentine and paint** may, in close compartments, prove dangerous, causing irritation of conjunctiva, nasal and respiratory mucous membranes, suppression of urine, and all symptoms of turpentine poisoning. A portable blower should be used to supply fresh air to such compartments, all openings of which should be wide open to facilitate ventilation. Certain paints possess the property of absorbing oxygen from the air and in a close compartment the percentage of oxygen in the air may be far below that necessary to support life. Compartments which have remained closed for some time, as well as double bottoms, should not be entered without previously having been tested by lowering a lighted candle into them. If the candle flame goes out the compartment should not be entered until it has been ventilated by opening thoroughly and using a portable electric fan connected with a duct which communicates with the external air.

I have treated a man who was overcome by the vitiated air of a closed compartment. He entered alone, going down a ladder. In a few seconds he called for help, and a comrade barely succeeded in rescuing him. Both men suffered immediate profound muscular weakness.

(*i*) Even with the most scrupulous care some odor will arise **from water closets and fouled scuppers.** These are flushed with sea water, but under common temperature and humidity conditions and considering how careless some persons are in the use of the water closet, it is not remarkable that odor will be present. Fortunately there is little danger from odor arising from decomposing dejecta, despite the trauma to our æsthetic sense. The danger here is rather from direct contact with door knobs, flushing handles, hand grips, railings and other objects which may be contaminated by means of hands soiled with urine or feces of possible carriers of infectious diseases.

(*j*) **Gases** emanating **from storage batteries** during process of

charging may vitiate the air seriously within confined spaces. Beck (Ueber die Bestimmung und den Gehalt an Schwefelsaüre in den Luft von Akkumuelatorenbattereien. Arb. a.d. Kaiserl. Gesundheitsamt, 1909, S. 77) has found so much as 1.51 milligrams of sulphuric acid in 100 liters of air in storage battery spaces. Carbonic acid gas, hydrogen, and water vapor also are produced. It should be remembered that when air is polluted by hydrogen to 10 per cent. or more by volume, an explosive mixture is developed which upon ignition may result disastrously.

(*k*) **Intestinal.**—Flatus may at times form a more considerable pollution of air aboard ship than may be supposed by persons unfamiliar with living conditions aboard ship. This pollution is more noticeable after certain rations have been eaten by the crew, *e.g.*, beans, etc.

2. Particulate Bodies

Particulate bodies found in air aboard ship just as in air on shore may be:

A. Inorganic;
B. Organic.

A. The **principal inorganic particulate bodies** in the ship's air are:

(*a*) Coal dust;
(*b*) Ashes and cinders;
(*c*) Street dust;
(*d*) Dust from chipping paint;
(*e*) Dust from combustion of explosives;
(*f*) Sawdust, etc.

(*a*) *Coal dust*, from the constant handling of coal, coaling ship, cooking, etc.

(*b*) *Ashes and cinders* from the combustion of coal. Ash is a minor factor as it usually is expelled by a steam ash ejector below the water-line and is satisfactorily disposed of. Cinders are a very different proposition. Under certain conditions of draught the coal is incompletely burned and large amounts of cinders are deposited on the decks, especially when steaming. Unless swept up frequently they cover the deck very soon.

(*c*) *Street dust* comes from the feet of many visitors as well as from the crew.

(*d*) *Dust from Chipping Paint and Scaling.*—This may be quite noxious. Cases of lead poisoning are seen from time to time in men who are scraping old paint or applying new.

(*e*) *Dust from Powder Explosions.*—When great guns are fired the atmosphere is filled with gases and ash resulting from explosion of several hundreds of pounds of smokeless powder. This air (surrounding the ship) gains access to the living spaces, and with the gases above mentioned causes marked respiratory and conjunctival irritation.

(*f*) *Particulate matter resulting from activities* of *crew, e.g.*, sawdust, filings.

B. **The principal organic particulate bodies are:**

(*a*) Bacteria from nasal, oral, and respiratory mucous tracts, and from suppurations and diseases in crew;

(*b*) Lint from clothing;

(*c*) Particles of food;

(*d*) Epithelial débris and hair from persons on board;

(*e*) Small particles of feces;

(*f*) Insects.

Man is the chief cause and source of transmission of man's infectious diseases.

(*a*) *Bacteria.*—Despite the tendency of hygienists to minimize airborne infections we must remember that on board ship:

1. There is over-crowding, rendering contact easy;
2. That the air is humid, tending to keep alive pathogenic organisms
3. That the air is warm, favoring life of germs;
4. That the air expired, coughed and sneezed may contain virulent organisms capable of living for some time under the existing conditions of temperature and relative humidity.

Bacteria from man are being thrown off by droplet method, and owing to close herding of members of the crew into small compartments the chances of (airborne) droplet infection appear very great. In this connection it must be remembered that a person artificially infected with *Bacillus prodigiosus* coughing in air in a closed room has sprayed out droplets containing living bacilli which were plated six hours after the person who "coughed up" the bacilli had left the room.

Neisser says *Bacillus typhosus, pestis, vibrio choleræ, Pneumococcus, Streptococcus pyogenes* are not spread by dust, but *Staphylococcus pyogenes* and *Bacillus pyocyaneus*, anthrax spores, *Meningococci* and tuberculosis are spread by dust (Prausnitz).

(*b*) Much *lint, cotton and woolen*, is apt to contaminate the air at times, especially at night or morning, or when a large liberty party

is preparing to go ashore and when many men are dressing or undressing. Living pathogenic bacteria may be present on the lint as well as upon:

(*c*) *Particles of food* which gain access to the air. It must be remembered that the men eat, sleep, and live in the same compartments.

(*d*) and (*e*) *Epithelial débris*, *hair* and comminuted dried fecal matter are also found in dust collected aboard ship. The possible danger of transmission of infection is seen here.

(*f*) *Insects*—mosquitoes, moths, flies, gnats, beetles—are taken in through ventilating intakes. They may play an important rôle in disseminating some of the transmissible diseases.

Air Analysis

Air analysis consists of: (1) physical examination, (2) chemical examination, and (3) bacteriological examination.

1. **Physical Examination.**—Physical examination consists in: (*a*) determining the temperature; (*b*) determining relative humidity; (*c*) determining atmospheric pressure with the barometer.

2. **The Chemical Examination.**—The chemical examination consists of a series of laboratory procedures which are impracticable on board a man-of-war, because the necessary apparatus is not available, and if it were the motion on board ship would result in breakage and inaccuracies which would vitiate results. Also because services of a skilled chemist cannot be had. In air and gas analysis accuracy of result depends upon extreme care and skill in the performance of the laboratory procedures. Carbon dioxide is the gas commonly estimated.

Carbon Dioxide.—CO_2 in itself seldom attains concentration enough in air to be really a serious factor for consideration. It is estimated only as an index of other pollution.

Occasionally a question will arise as to the CO_2 content in a given space.

The rough **method of Wolpert modified by Bohm** is readily available, requires no elaborate apparatus, and may be used to advantage. Take about 20 c.c. of limewater in each of two test-tubes of equal size and thickness.

Ascertain how many fillings of the rubber bulb with fresh air outside will be needed to render the limewater just turbid enough to obscure a pencil mark on white paper placed under the tube and viewed from above.

Then similarly test the suspected air. If we assume that the outside air normally contains 0.03 per cent. CO_2 and it takes 15 fillings of the bulb while only 5 fillings of the suspected air produce the same turbidity, we may consider that

($15/5 = 3$) suspected air has three times the concentration of CO_2 that the outside air has. Outside air is most probably 0.03 per cent.; then $3 \times 0.03 = 0.09$ per cent. in suspected air. This test is accurate enough for practical work.

Recently **Higgins and Marriott have devised a colorimetric method** of determining the CO_2 percentage in the air. It depends upon the reaction of a solution of sodium bicarbonate through which the air containing CO_2 has been passed until saturation has been attained.

This reaction will vary with the CO_2 tension in the air which has saturated the sodium bicarbonate solution. Low pressures of CO_2 will change the reaction toward the alkaline side, while high pressures increase the acidity.

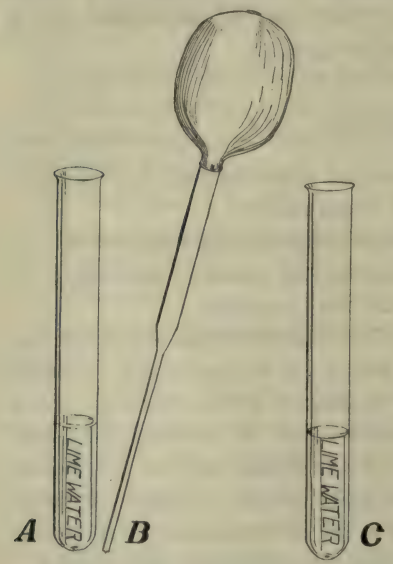


FIG. 8.—The apparatus necessary for rough estimation of carbon dioxide content in the air after the method of Wolpert as modified by Bohm.

The addition of phenolsulphonephthalein to the sodium bicarbonate solution as an indicator gives a colorimetric gauge of the reaction.

The comparison of the color of the solution under standard conditions with that of previously prepared standard solutions of varying reaction and of known strengths enables a colorimetric reading of the actual percentage of CO_2 in the air tested.

This reading is direct and requires no corrections for temperature unless it is below 20°C. or above 25°C.

Similarly no correction for pressure is required between 730 and 800 millimeters, *i.e.*, no correction for the sea level, 760 millimeters.

The method is unique, quick and convenient. It is open to the objections that:

(*a*) The colored standard solutions are unstable and become unreliable after a few months;

(*b*) The method depends upon color perception and color comparisons;

(*c*) The tests are of such delicacy that the readings may be badly vitiated by the slightest impurity in the chemicals used or by expired air of the operator.

Carbon Monoxide.—Carbon monoxide is the only other gaseous impurity of air worth our consideration at this time. The most reliable test for it is the spectroscope. Usually it is not available. Birds and mice or other warm-blooded animals have been used in confined spaces, as they are affected by CO much sooner than man.

Paper saturated with a solution of palladium salts will blacken in

presence of CO. The quantitative estimation of this gas is a laboratory problem seldom soluble with available apparatus on board ship.

3. **Bacteriological Examination.**—Bacteriological examination of air may be: (*a*) qualitative; (*b*) quantitative.

(*a*) For the *qualitative* estimation of microörganisms in air the Petri method is best. By this method a plate of lactose litmus agar is exposed to the air for five minutes. The area of the plate is 100 square centimeters and the five-minute exposure is supposed to give the number of organisms present in 10 liters of air. Isolation of the colonies and culture gives the varieties present. Stitt states that an exposure of ten minutes instead of five will give results which make this method a satisfactory quantitative procedure. He states: "The simplicity and ease of access to the colonies developing on it (the Petri plate) make

FIG. 9.—Sedgwick-Tucker aerobiscope. (*Mac Neal.*)

it preferable when the air of operating rooms or hospital wards is to be examined."

(*b*) The *quantitative* method devised by Sedgwick in which the Sedgwick-Tucker aerobioscope is used should be mentioned. The aerobioscope is a glass instrument which has a support in one end and upon this granulated sugar is poured in a thin layer, the aerobioscope having been previously sterilized. The instrument and sugar are then resterilized in dry heat at a temperature not exceeding 120°C., to avoid melting the sugar. A given quantity of air is then drawn through the sterilized sugar. The latter is shaken down into the large chamber of the instrument and 10 or 15 c.c. of melted gelatin are poured in upon it. The tube is now rolled, as in making roll cultures and incubated at room temperature. After this the colonies may be counted and the number per liter may be estimated.

Rettger's method is an excellent one: A given quantity of air is bubbled through salt solution. The bacteria in the air are caught in the solution and may be plated, incubated, and counted by the methods commonly employed in bacteriological work.

CHAPTER VII

VENTILATION

Man's Requirements

It is generally agreed that where it is possible the adult should have an air supply of 3000 cubic feet per hour, never less than 2000, in order to dilute his own gaseous exhalations to a point where the CO_2 will not exceed 6 or 7 parts per 10,000. (It must be borne in mind that the carbon dioxide component in any atmosphere ordinarily breathed by human beings may be regarded as negligible from the sanitary standpoint, except in so far as its increase within closed spaces, such as rooms, etc., may be interpreted as an index of the corresponding increase in temperature, humidity, and volatile products from alimentary and respiratory tracts, as well as the skins and clothing of occupants of such spaces.)

Additional allowance should be made for spaces where excessive CO_2 or other gaseous pollution may occur.

Pettenkofer demonstrated that 2500 cubic feet of air may be passed through a space of 424 cubic feet in an hour without producing perceptible drafts. So that in a room 8 by 8 by 6.5 feet the air could be renewed six times per hour without discomfort from drafts. When the air in a given space is changed oftener than three to four times per hour, *i.e.*, if the cubic capacity of a room be completely changed more than about four times per hour drafts are apt to be felt somewhere in the space. This then would mean that the minimum air space per man would be $3000 \div 4 = 750$ cubic feet per man, per hour.

In barracks and habitations on shore considerable ventilation occurs imperceptibly through the chinks and cracks in the walls at and around the natural openings, such as doors and windows. In addition to this it must be remembered that a number of building materials possess considerable permeability for air, and far more transpiration occurs through unpainted brick or wooden walls than generally is realized. It is stated that an average unglazed brick will absorb about one pint of

water, which, in view of the composition of brick, is tantamount to saying that a brick contains a corresponding amount of air.

The permeability of unglazed brick well may be illustrated in the following manner:

With sealing wax the mouths of two glass funnels are fastened on to the uncovered surface of a brick, and all the area of the brick except that covered by the mouths of the two funnels is completely coated with sealing wax, thus preventing absorption or escape of air.

One funnel is connected to a bottle, the rubber stopper of which contains two perforations, one for a glass terminal tube leading from the funnel, and opening into the air chamber in the bottle, above the water which partially fills it. Extending through the second opening in the stopper, and below the surface of the water, is a thistle tube through which water may be poured, thus increasing the volume of water in the bottle, and correspondingly decreasing (for all practical purposes) the contained volume of air. This air is forced out through the tube, enters and passes through the brick, and if a rubber tube be connected with the funnel attached to the opposite side of the brick, and the distal end of this tube submerged in a basin of water, the escape of air from the bottle through the brick will be made evident by the bubbling of water in the basin.

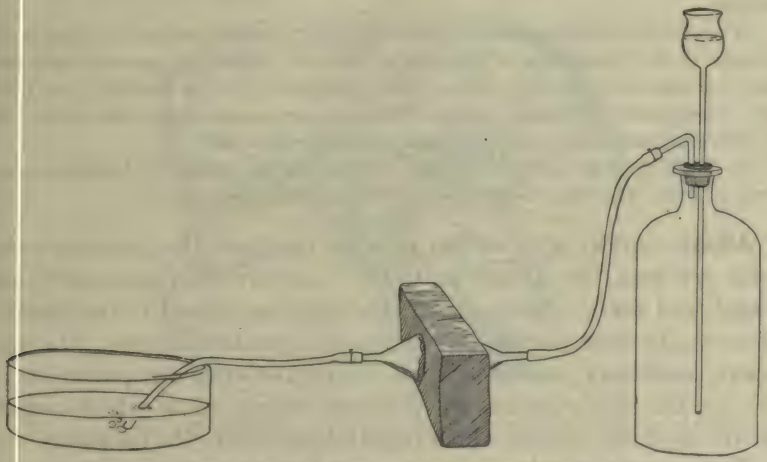


FIG. 10.—Apparatus to demonstrate permeability of brick.

Glazed brick, painted surfaces, or papered interior walls, limit this natural passage of air through the walls.

Soldiers in barracks should have *at least* a 6-foot by 10-foot floor area with a 12-foot ceiling. The above are minimum figures. The more space the better within reasonable limits.

Life aboard ship is essentially a life of over-crowding. Space is given to munitions, stores, coal, machinery, etc., and the available air space is reduced far below that ordinarily regarded as necessary to man's welfare on shore. It is questionable whether the most crowded tenement "rookeries" will show smaller per capita air space.

A classical case of disaster due to over-crowding at sea is that of the "Londonderry," which was caught in a storm while making passage between Sligo and Liverpool in 1848. Owing to the severity of weather it became necessary for their safety to confine two hundred steerage passengers in a poorly ventilated compartment which afforded less than 7 cubic feet of air space per person. More than 70 out of the 200 were found dead when the compartment was opened on the following morning.

Of course such conditions are unheard of today, but this instance is cited as the analogue of the Black Hole of Calcutta on shore, in which 146 prisoners were confined over night in a military prison, the air space of which was less than 5900 cubic feet. There were two small windows, but these were on one side of the room. On the following morning 123 of the prisoners were found dead.

No doubt the high temperature and humidity in the latitude of Calcutta added much to what otherwise would have been intolerable conditions.

Afloat.—Afloat it is seldom possible to attain the desirable cubic space per man, for a merchant ship is a carrier of passengers and freight, and every cubic foot of space must be utilized to the greatest advantage in order to yield the maximum return to investors. On men-of-war, machinery, munitions, fuel, stores, and other equipment necessary for the ship's paramount function occupy space which reduces greatly the cubic volume which could be allotted to the personnel.

The crew in its sleeping places on board ships of the following navies has cubic air space as given below, by the authorities cited:

	Cubic meters		Cubic feet
German Navy (Plumert)	1.5 –8	=	47–250
British Navy (Beadnell)	4.24–8.2	=	132–250 (249.6)
Italian Navy (Belli)	4.55–10	=	141–312
U. S. Navy (Gatewood)	5.6	=	165

The sick bay on the U. S. S. Pennsylvania has a cubic capacity of 320 cubic feet per capita. The air in this space is changed every eight minutes by combined supply and exhaust systems. In the German Navy 468 cubic feet per capita is given as the allowance of air in sick bay, but the rate of change is not given.

In officers' cabins the ships of the United States and Germany give

about 25 cubic meters = 780 cubic feet. Those of the Italian Navy have 12 cubic meters = 375 cubic feet.

In 1910 the British Admiralty appointed a commission of prominent civilian and naval authorities to study prevalence, prevention and results of tuberculosis in the British Navy. This commission established a fixed minimum standard of 200 cubic feet of air space per individual.

On the recently constructed Pennsylvania class (United States Navy) the officers' staterooms are given a cubic capacity of 800 cubic feet, and the crew 150 cubic feet per hammock.

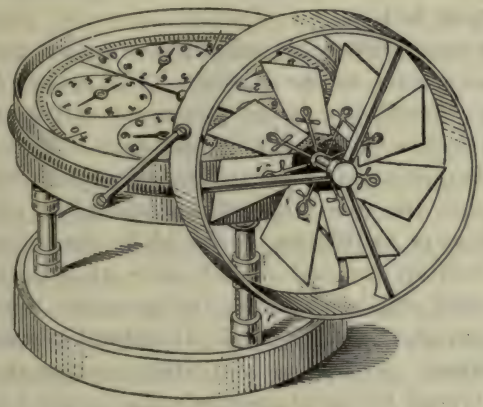


FIG. 11.—The anemometer. It is used for measuring the velocity of currents of air.

When it is considered that at least one-third of the crew is always on watch, and that in port large liberty parties are on shore it will be realized that the air space just mentioned is more liberal than it appears. Just here attention is called to the open character of sleeping spaces for the crew on board ship. Many ships, especially men-of-war, have their berthing spaces unbroken by bulkheads, as for instance on the gun deck where the hammocks swing as if in a large hall rather than in several small rooms. This absence of bulkheads facilitates both natural and artificial air change, and in such large compartments the cubic air spaces per capita may be smaller than would be comfortable in small rooms whose aggregate volume equals that of the large space. On the Pennsylvania we observe that the air space in the small officers' staterooms is 800 cubic feet, whereas on the more open decks 150 cubic

feet per capita suffices. The air can be changed ten to twelve times per hour in large spaces, but in the small spaces it may be changed not exceeding four to six times without discomfort.

The medical officer should make regular observations with wet and dry bulb thermometers in all working and living spaces, and if the air supply seems unsatisfactory, specimens of air should be taken for analysis.

To supply the necessary volume of fresh air the minimum cubic space per capita allotted for small rooms ashore is 750 cubic feet, but in large buildings, such as halls, theaters, and churches, the air may be changed oftener without discomfort and the per capita air space is placed at 300 cubic feet.

Finally, we must deliver 3000 cubic feet of air per man per hour to supply his requirements, ashore or afloat. This is done by *ventilation.*

Ventilation.—Ventilation is the process of withdrawing air laden with gases, particulate matter, and bacteria from an enclosed space and replacing it with pure air of proper temperature, humidity, and motion. In order to prove effective this exchange should be continuous. In the consideration of ventilation it should be remembered that this exchange of fresh air for foul should occur at the breathing zone. Whether on board ship or on shore the necessary ventilation of air spaces is accomplished by means of (1) **natural ventilation** and (2) **artificial ventilation.** By natural ventilation is meant the air exchange which occurs through the usual openings of an inclosed space as result of natural causes. Artificial ventilation effects exchange of the air by mechanical means.

Natural Ventilation

Natural ventilation is ventilation resulting from operation of the following natural causes:

(*a*) Difference in temperature and consequent difference in pressure;
(*b*) Perflation;
(*c*) Aspiration;
(*d*) Diffusion;
(*e*) Humidity;
(*f*) Motion of man, animals, and objects moved incident to man's activities.

(*a*) **Difference in Temperature.**—When a given volume of air is heated, it expands, and becoming lighter, rises. These physical

characters are the causes of air interchange which is due to pressure differences caused by temperature differences. The air from a point of high pressure flows toward the area of low pressure; hence as the heated air rises currents of cold air rush in to take its place. Morin studied this problem and found that 400 cubic meters of air escaped through the chimney of his study each hour when there was only 21°F. difference between the air in his study and the air outside. This pressure difference dependent upon temperature difference in the air on a grand scale is responsible for all of our winds in nature, therefore of course (*b*) perflation and (*c*) aspiration fundamentally are dependent upon thermal difference.

(*b*) **Perflation** acts when the wind blows in such a way that the resultant of its force sets up air currents and blows through an enclosed space. Drafts are caused in this way.

(*c*) **Aspiration.**—A current of air passing by an opening in an enclosed space tends to extract air from the space, although the causative air current does not actually enter. This principle is often found of value in ventilating enclosed spaces.

(*d*) **Diffusion.**—Air being a mixture of gases follows the physical laws applicable to gases.

(*e*) **Humidity.**—Moist air being lighter than an equal volume of dry air under the same conditions of temperature and pressure, tends to establish upward currents when coming in contact with dryer (heavier) air.

(*f*) **Motion of Man, Animals, and Objects Moved Incident to Man's Activities.**—Natural ventilation also is caused to some extent by the motion of air resulting from the movements of animals, man, and objects connected with his activities, for instance: railway trains, steamships, automobiles, machinery, etc.

For natural ventilation hygienists allot to each occupant of an enclosed space at least 24 square inches of window space. This allowance is too small.

On board ship natural ventilation differs materially from that ashore. The employment of steel in constructing the hulls of ships renders impossible any natural ventilation through the ship's side other than that through the natural openings. If a ship's hull is water-tight, it must also be air-tight. Transpiration through the impermeable steel does not occur.

Below the water-line, for purposes of safety, merchant ships as well

as naval vessels usually are divided into water-tight compartments, which commonly are closed except for inspections, drills, cargo storing, cleaning, and repairs incident to the upkeep. Often such compartments have only a single opening into them, namely the hatch through which merchandise or stores may be loaded and unloaded. Manifestly such a compartment resembles somewhat a bottle which has a single opening at the neck, and here natural ventilation cannot be depended upon to supply the adequate amount of fresh air for the proper aeration of such spaces. Double bottoms, wing passages, and other compartments which usually are kept closed should be entered with caution because of possibility of air pollution or absorption of the oxygen content by paint (or other oxidizable matters) below the percentage required for maintenance of life.

Above the water-line the subdivision of deck spaces by water-tight bulkheads does not hold to the same degree, especially on freight ships and naval vessels. Consequently there is less interruption of the sweep of air currents which gain entrance through natural openings. On passenger ships, however, the cubicle or cellular system of subdivision of spaces between decks is a necessity if passengers are to have staterooms. In such constructions there is essentially great interference with natural ventilation.

Local temperature differences operate here to a very remarkable degree. The large amount of heat generated in making steam, conducting steam through steam pipes to auxiliary machinery, distillation of water, cooking, etc., causes the air within those spaces to be heated rapidly, thus tending to force the lighter hot air upward, establishing air currents which bring in air from the outside of the ship. If, however, the temperature in the external atmosphere is above 90° some of these currents may be reversed, the warmer outside air tending to enter the usual channels of exit. The sunny side of a ship is warmer, and the air on that side tends to rise, thus establishing currents of cooler air toward that side. The same may be said of heated bulkheads or portions of spaces through which steam pipes run. The windy side of a ship will be subjected to more rapid evaporation and cooling, consequently air currents may go from the cool side to the warmer.

Natural ventilation of a ship occurs through permanent openings in her decks or hull, such as:

1. Hatches, or openings in the deck for access to spaces below;
2. Ventilating cowls or shafts;

3. Air-ports or windows in the ship's sides;
4 Smoke pipes and smoke-pipe casings;
5. Elevator shafts;
6. Chutes;
7. Voice tubes;
8. Cargo ports on a merchantman;
9. Ammunition hoists;
10. Gun-ports on a man-of-war.

1. **Hatches** are openings in a ship's deck made for access to spaces below, and may be closed and made water-tight.

2. **Ventilating Cowls and Intakes.**—Ventilating cowls are heavy metal tubes of large diameter, extending through and well above the decks, terminating in a flaring mouth which revolves and may be directed ("trimmed") toward the wind. The mouth of a cowl should be covered by a wire grating to prevent persons falling down, or large objects being thrown through the cowls. The lower end of a cowl terminates in a system of tributary air ducts going to different compartments.

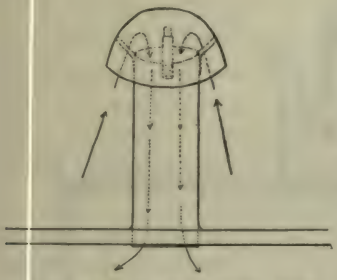


FIG. 12.—A mushroom cowl. The arrows indicate the course of air entering under the hood of the cowl and going down to the compartment below.

The so-called mushroom cowl is covered by a strong metal cover which gives the cowl its name.

The most efficient cowl is so constructed as to deflect water centrifugally and drain it away when the vessel "ships a sea," yet it enables air to enter (Courbet type).

Frequently a bitt is utilized as a small ventilating cowl. It has a fenestration opening into its hollow interior, and communicating with a space below the deck from which the bitt projects.

A common application of the principles of perflation and aspiration is seen in the trimming of ventilating cowls.

One cowl is trimmed ("trained") so that the plane of its mouth is perpendicular to the course of the wind. This position enables the entrance of a maximum quantity of the moving air, which is directed downward and through the compartment—perflation.

On the opposite side from the wind, the lee side, the mouth of the cowl is directed away from the wind, thus causing the passing wind to

aspirate from its mouth currents of air which are drawn from the compartment below—aspiration. Here perflation and aspiration by their combined action tend to force in fresh and exhaust foul air from the compartment.

Ventilating cowls have variously modified mouths, each being supposed to possess some special merit. In general it may be said that the simpler the construction of intake (or mouth) the better.

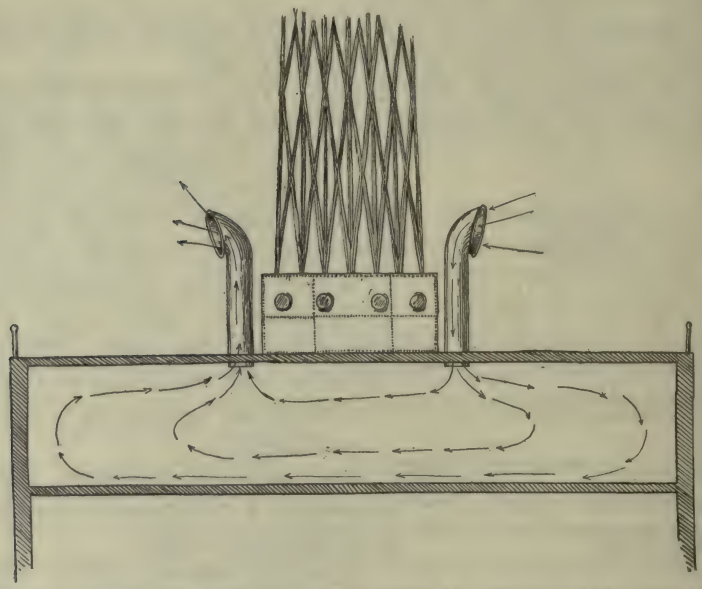


FIG. 13.—Ventilating cowls trimmed to facilitate perflation of the deck below. One cowl is trained to receive the wind, the other, trained in the opposite direction, serves as an exhaust. The arrows indicate the direction of air currents.

3. Air-ports are openings, usually circular, in the steel side of the ship, and serve the same function as windows in buildings on shore—permitting the flow of air in and out and admitting light. Air-ports are closed by circular frames snugly fitting upon rubber gaskets making water-tight joints. The frames are filled with a very strong "dead-light" or glass which admits light even if the port must be closed to prevent entrance of water from a rough sea.

4. Smoke Pipes and Smoke-pipe Casings.—The smoke pipes from the fire room by reason of the draft caused by the ascent of heated air aid materially in ventilating the spaces from which they may draw.

On the same principle the space between the smoke pipe and its casing is utilized as an exhaust for air contained in its tributary spaces.

5. Elevator shafts serve as uptakes and permit rise and exit of heated, humid air vitiated in spaces below.

6. Chutes or **Scuttles,** tubular channels for loading cargo in bulk, coaling ship, etc., serve similar purpose.

7. Voice tubes aid natural ventilation in a small way, yet it is easily conceivable that such a tube, by virtue of its communication with respirable air, might save a life in a compartment filled with water or irrespirable gases.

8. Cargo ports are for loading cargo. They are large windows opening into the ship's side, and are closed by means of steel shutters, which, when closed, make water-tight joints. As these ports open between decks, their uses in natural ventilation are obvious. If it is not cold they may be kept open in good weather.

9. Ammunition hoists are modified elevators for carrying ammunition from one deck to another. The shafts through which these carriers pass serve also the purposes of natural ventilation.

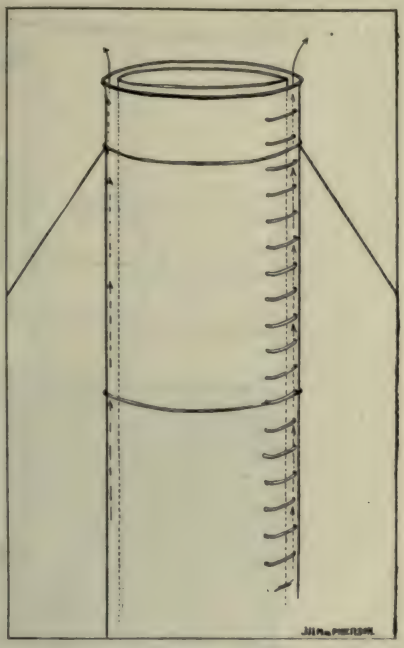


FIG. 14.—A sketch showing how the interval between the smoke pipe and the smoke-pipe casing may be used as a ventilating uptake. The arrows indicate the direction of the draft.

10. Gun-ports are the openings in the side of a warship through which the guns pass and are trained. Gun-ports are large and afford good natural ventilation to the spaces into which they open.

The desire to utilize natural ventilation to the fullest extent on board ship has led men, in addition to natural openings, in the deck and hull of a ship, to employ:

1. Scoops;

2. Windsails;

3. Screens.

These are devices for deflecting the wind effectually into the ship's natural openings.

1. *Scoops* usually are made of galvanized iron plates bent into a scoop shape. At one end of the scoop-shaped plate is attached a collar which snugly fits into the air-port, as the circular window in

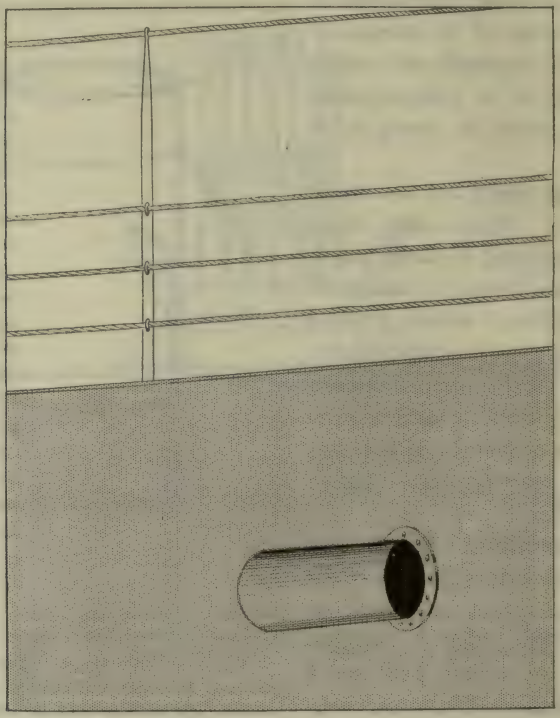


FIG. 15.—The scoop is projecting out of an air port and would deflect an air current through the air port into the room within. Note the life lines above. They surround the deck and prevent falling overboard.

the ship's side is called, and holds the scoop in place after it is thrust through the air-port. The other end of the scoop presents a graceful rounding of its corners. The margins of the scoop are stiffened by being rolled over so as to form a miniature tubular channel.

Scoops vary in size, the radius of their curvature varying with that of the air-port through which the scoop is designed to extend.

When the scoop is in place, it projects about 2 feet from the ship's side, and deflects the air striking it into the air-port through which it projects. Obviously its efficiency depends upon the velocity of air currents met by it. The scoop is a most useful aid to natural ventilation of spaces between decks.

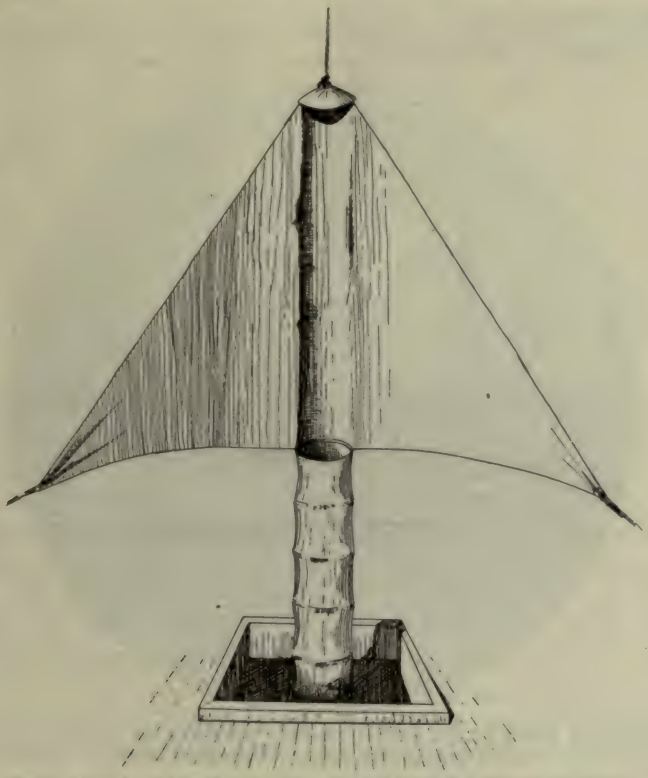


FIG. 16.—A windsail extending down through a hatch on deck.

2. *Windsails* are canvas funnels or tubes having spreading wings on each side near the top, which is closed. Windsails may be stayed so as to catch the wind and deflect the moving air down the canvas tube into the spaces between decks, thus facilitating natural ventilation. Wooden hoops placed at intervals serve to keep the windsails patent.

3. *Screens.*—Canvas screens lashed to stanchions sometimes may

prove very useful in deflecting wind downward through a hatch. Often, however, the hatch cover may be made to serve the same purpose, provided the wind comes from the right direction. The hatch covers being hinged to the coaming are not always available, as they cannot be spread to the wind coming from all quarters as can screens.

Conditions Affecting Natural Ventilation.—Natural ventilation of ships is affected by:

1. Velocity of the wind;

FIG. 17.—A vessel in the tropics showing windsails set, awnings spread and "scrub and wash clothes" on the clothes lines.

2. Speed of the ship;
3. Direction of the wind;
4. Course of the ship;
5. Differences peculiar to the locality through which the ship may be passing.

1. The **natural ventilation** of a ship "dead in the water" **is modified by the velocity of the wind** blowing past it—the greater the velocity within limits of safety, the greater will be the effect of the resulting

perflation and aspiration. The effect is analogous to the effect of wind upon a building on shore.

2. Ships are "dead in the water" but a small portion of their time. One of their functions is to move about. The **speed** with which a ship moves **modifies** the effect of the wind's velocity upon **natural ventilation** of her spaces.

A ship proceeding at the rate of 15 miles per hour in the absence of wind makes for herself an air current of about 15 miles per hour, due to her motion. If she is steaming into a head wind having the rate of 15 miles per hour, for purposes of natural ventilation the ship is encountering a wind whose rate is equal to that of the actual velocity of the wind plus the rate of the ship's speed. If however the ship is going at the same rate of speed, 15 miles per hour, and a wind having velocity of 15 miles per hour is blowing from astern, the effect upon natural ventilation practically would be to neutralize the air currents in such way that the air about the ship would seem stagnating. In the Red Sea at times the temperature is so high, and the winds are of such character, that in order to give relief to the oppressed crews in the engine rooms it has been necessary to turn the ship completely around and to steam in the opposite direction in order to ventilate thoroughly the lower spaces.

3. The **direction of the wind** may have the effect of greatly augmenting or completely neutralizing the air currents established as result of the ship's own motion. The wind coming abeam (90° from the way the ship is heading) has excellent effect on ventilating the ship's spaces which are open, since the wind or breeze tends to blow more directly through the ship than is the case when the wind is dead ahead or dead astern. The maneuvering of war vessels in which they are moving about on the water as a company of soldiers drills on shore, heading first in one direction and then another, is a powerful adjuvant to natural ventilation. It is believed that the effect of the ship's maneuvering is greater upon her contained air volume than generally is realized.

4. **Course of the Ship.**—Natural ventilation is modified by the course of the ship in that her course determines her relation to a given wind, whether she meets it, whether the wind is following, or whether from another quarter.

5. **Differences peculiar to the locality** through which the ship may be passing. In certain localities well-recognized air currents are prevalent during certain periods of the year. For instance the trade winds, and the *monsoons*. Again there are sections where periods of great calm are experienced. Every sailor dreads the Doldrums. Sails do not draw, and vessels depending solely on the wind are left for days, mak-

ing little progress on their course. Obviously the localities where trade winds are prevalent would modify natural ventilation.

Along the coasts in various parts of the world a breeze from sea blows toward the land for about twelve hours, and then the wind shifts, blowing from the shore. Within the sphere of influence of this wind, for instance in harbors and in coastwise cruising, natural ventilation of ships is materially facilitated by these alternating winds.

The swinging of a ship at anchor in adapting herself to the wind and tide modifies natural ventilation accordingly.

Artificial Ventilation

Artificial ventilation consists in the constant and mechanical exchange of air contained in a given space for an adequate supply of fresh, pure, atmospheric air which may or may not be conditioned (heated, cooled, or humidified), and which is kept in gentle motion, especially in the breathing zone.

On Shore.—The apparatus used for artificial ventilation ordinarily consists of a large chamber containing a fan or blower, the chamber having communication through a duct with the air external to the building, and the opposite side of the chamber communicating with a system of ducts which enter the various spaces to be ventilated. The fan or blower commonly is driven by an electric motor. Depending upon the direction for which it is designed to operate, the apparatus may draw air from the exterior, passing it through the chamber and expelling it as fresh air through its system of ducts, which may be compared to bronchial tubes. If designed to operate in the opposite manner, the fan will draw air from the various ducts above mentioned and expel it into the atmospheric air outside the building. Thus it will be seen that there are three systems of artificial ventilation which may be used:

1. The plenum or supply system;
2. The exhaust system;
3. A combination of the plenum and exhaust systems.

1. The **plenum or supply system** is that in which the fresh air is drawn from without and supplied by means of a rotary fan or blower to the spaces to be ventilated. For most spaces this is the best system of artificial ventilation if it is not practicable to combine it with the exhaust system. The intake for atmospheric air should be situated as high as possible on the building in order to avoid much of the dust

in the lower air strata. The intake should further be carefully placed with reference to chimneys or other sources of air pollution in order to avoid distributing vitiated air throughout the building. The intake should be carefully screened against insects.

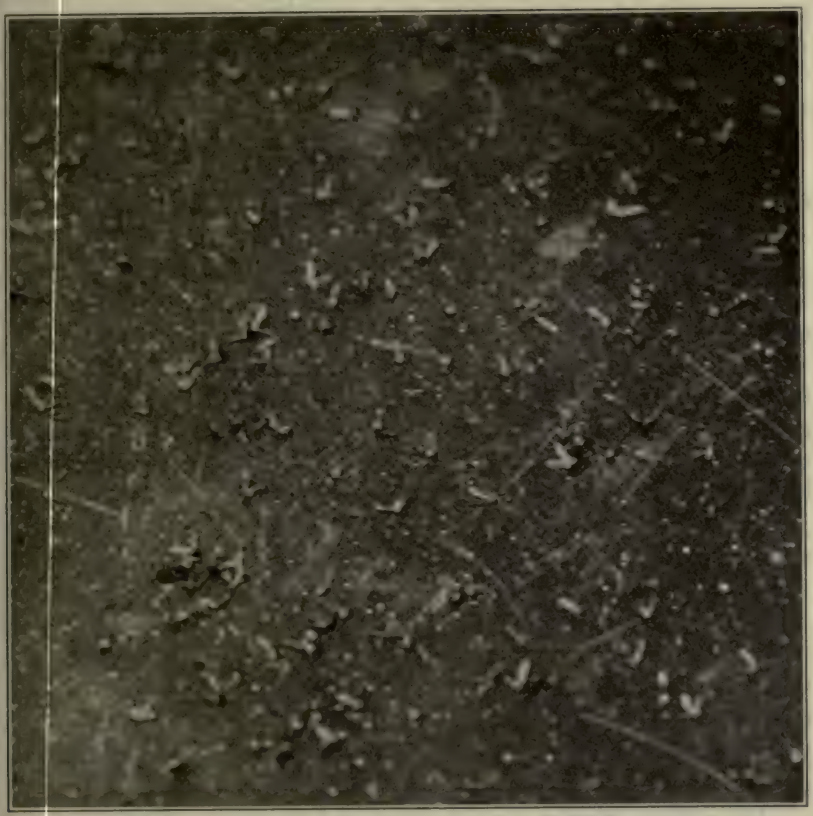


FIG. 18.—Flies and insects, some living and some dead, which had passed by the powerful rotary fan and were distributed to the decks below. The above picture was taken at the outlet of a supply louver and shows the insects on deck in an ammunition passage; *i. e.*, well below the ship's water-line.

The terminals of the various distributing ducts vary in pattern and location.

Type of Terminal Devices.—Numerous ingenious devices have been employed as terminals for the air ducts, but it is believed that perhaps

the best is merely the expansion of the duct in the form of a truncated cone, the base of which constitutes the ultimate terminal of the duct.

Location of Terminals.—The terminals in the plenum system of ventilation should be located as nearly as possible in the breathing zone, yet they should be so placed that they may not produce drafts uncomfortable to the occupants. Terminals at the floor level tend to distribute the dust contained in the lower air strata, and also in cold weather would deliver cold air around the feet of the occupants of the spaces. Consequently this location of terminals is undesirable.

In our latest ships the louvers are placed at a level of about three feet above the deck, and the air current is directed horizontally to avoid raising dust from the deck.

In certain localities where insects are numerous these terminals should be screened with ordinary screening wire, eighteen meshes to the inch.

In large cities where there is a great amount of dust it has been found advisable to interpose between the intake and supply fan one of the several forms of air washers, thus freeing the air of its dust content, and likewise humidifying it before distributing throughout the building.

It will be observed that in the plenum system provision is made for supplying fresh air, but the vitiated air is left to escape through the natural openings in the building.

2. The **exhaust system** is a reversal of the above described plenum system. Instead of supplying fresh air and allowing it to escape through natural openings, the exhaust system withdraws the vitiated air from the building, discharges it into the outer air, and makes no provision for admission of fresh air except as it may come in through natural openings to take the place of the withdrawn foul air.

This system possess disadvantages and should be employed alone only in places where great heat, humidity, injurious gases and dust or disagreeable odors should be removed.

Instead of delivering fresh air into the compartments the exhaust system tends to draw into the compartment any foul air which may be in the vicinity of the natural openings of the chamber.

3. **The Combination of Plenum and Exhaust Systems.**—The combination of plenum and exhaust systems appears to be the ideal, as the plenum fan supplies the fresh atmospheric air and the properly

located exhaust fan withdraws the vitiated air from the building, thus maintaining a constant supply of fresh air in gentle motion.

Aboard Ship.—Ships spend the major portion of their time in atmospheric air of exceptional purity; despite this fact natural ventilation is totally inadequate, because:

(*a*) The wind is inconstant;

(*b*) Sufficient natural openings are incompatible with the necessary strength of the hulls and deck;

(*c*) Rough weather at sea causes closure of natural openings in order to exclude water;

(*d*) To deliver sufficient fresh air, ducts would have to be too large, too heavy, and too expensive. Consequently artificial ventilation must be employed.

As on shore, the three systems of mechanical ventilation are used, namely, plenum, exhaust, or the combination of the two. The necessity for the maintenance of integrity of water-tight bulkheads on board ship modifies very materially the artificial ventilation of ships, and since these bulkheads should not be pierced below the waterline beyond imperative necessities, it is impossible to employ a single ventilating system of ducts in the living spaces, as flooding of one compartment probably would result in the flooding of others through the ventilating ducts. Each water-tight compartment must have its individual system of artificial ventilation. It must have its intake, its distributing fan, and ducts leading therefrom. The intake for the fan should be located in the superstructure where the high seas of a gale will not affect the ventilating system.

In determining the quantity of air required in a given compartment the following factors should be considered:

1. The number of occupants;
2. The character of activity of occupants, whether sleeping, resting, or engaged in arduous work;
3. The location of the compartment with reference to engine room, fire room, and hot spaces;
4. Exposure of boundaries of the compartment to weather. Obviously an inner compartment will require greater supply than one which may have an opening into external air;
5. Whether the vessel is designed specially for tropical service;
6. The probable generation of excessive heat; the presence of great humidity or of gaseous pollutions;
7. Location and effect of openings into the compartment upon the contained air.

So important is the subject of ventilation considered in the British Navy that one commissioned officer is detailed as Ventilation Officer. This officer may or may not be the senior medical officer. If not, he is required to keep in close touch with the senior medical officer in order that the best results may be obtained from careful supervision and nice adjustment of the ventilating apparatus.

The plenum system combined with natural exhaust should be used on board ship in every compartment where it becomes necessary to supplement natural ventilation, except in cases where there are great heat or great humidity, deleterious gases, bad odors, or possible infections. The exhaust system should be employed in such circumstances. The plenum system would tend to force foul air and bad odors from the compartment in which they were generated to adjacent compartments, and here we would see the paradoxical effect of a purifying stream of air causing pollution of air contained in the nearby spaces. In an engine room, laundry, steering engine room, and in other heated compartments, the exhaust system of ventilation should be employed for removal of over-heated air, or should be connected with the smoke-pipe casing. In wash room, firemen's wash rooms, and the various water closets the exhaust system should be installed. The isolation ward should be equipped with a strong exhaust system, having communication with no other compartment. There are certain compartments on board ship, such as a central station and sound-proof telephone booths, which should be well supplied with plenum ventilation.

Whether the supply or exhaust system be employed, sufficient openings in the ducts should be provided to enable their thorough cleaning. A considerable amount of dust and lint accumulates in the air trunks in a very short time and may be distributed generously throughout the ship by changes in rate of fan and jarring incident to gun fire. Dead insects often are found in these trunks.

Unless intakes are screened carefully against flies and mosquitoes, the ventilating system may be an active factor in distributing living insects between decks, if the ship happens to be lying in a region infested with them. In such circumstances it is not uncommon to find numbers of insects, some dead, some injured, lying on the deck near the outlet of the duct supplying fresh air.

During the summer of 1915, while the "North Dakota" was lying at the Navy Yard, Philadelphia, I saw an 18-inch intake on the forecastle almost wholly occluded by a layer of mosquitoes and moths. In some places this layer was ½ inch

thick. The intake had been screened to prevent entrance of insects. A standing light on deck near the intake had attracted the insects to within the sphere of influence of the fan, where they were held, many dead and some living, by the aspirating effect of the fan which was drawing in fresh air.

FIG. 19.—The screened mouth of a large ventilating intake almost completely occluded by mosquitoes and other insects. The suction of the powerful fan held the insects against the screen until a layer almost a half inch thick had been accumulated.

Intakes for fresh air which are near the butcher shop, galley, or vegetable lockers on deck should always be screened. Decomposing vegetable matter, such as onions, potatoes, beets and cabbage, form excellent breeding places for flies, and unless the openings are screened

the ventilating system may carry young flies down into the fan chamber, whence they may be distributed in the spaces below.

In time of target practice or in action the plenum ventilating system may prove to be a distributor of dangerous gases of combustion. Of

FIG. 20.—Potato lockers on deck.

course the quality of these gases is dependent upon the chemical composition of the explosives used. It becomes especially necessary to consider methods of protection against gas shells. These are missiles containing compressed noxious gases, which shells explode at time of impact and liberate their poisonous content.

During the Russo-Japanese War the danger of gas poisoning became prominent.

In the battle of Jutland it became necessary to stop the supply fans of the ventilating system in order to prevent delivery to the spaces below of poisonous gases arising from gun fire and from gas shells.

The ventilation committee appointed by the British Admiralty, after a careful study of artificial ventilation on board ship, has recommended a new system of trunks and terminals with a view to reduce the drafts and to distribute evenly the supply of fresh air forced through the ventilation system by fans.

Fleet Surgeon R. C. Munday, R. N. (*British Medical Journal*, No. 2939, p. 538) gives the following brief and interesting description:

The principle of the new system which has now been adopted in our most recent battleships and cruisers is that by means of an adjusted deflector projecting into the air duct a limited flow of air is directed into a large number of outlet gratings.

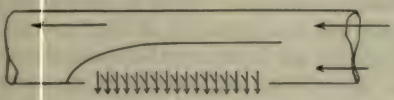


FIG. 21.

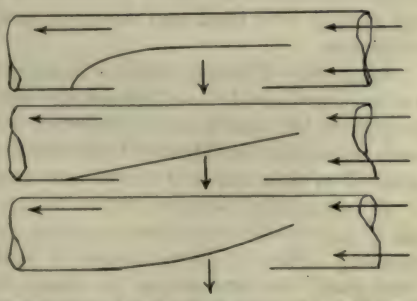
It was found that with a suitable but very simple and inexpensive form of grating the air passes out through it with a fairly uniform velocity at all parts. As, however, the area of the grating is considerable in proportion to the air allowed to issue through it, the velocity of the issuing air is low, and no unpleasant draught is perceptible at more than a foot away, even when 100 cubic feet of air a minute are issuing from a grating of 18 by 6 inches. The grating is made of expanded steel, and it was found that a three-eighths of an inch mesh placed so that its direction tended to deflect the air at right angles to the trunk thus:

Fig. 21 produced the best effect at a minimum of cost and weight. An endeavor was then made by varying the curvature of the deflector to obviate the inequality of distribution over the face of the grating, and experiments were made with deflectors:

FIG. 22 (*a*) Concave, thus:

FIG. 23 (*b*) Straight, thus:

FIG. 24 (*c*) Convex, thus:



FIGS. 22, 23, and 24.—Sections of ventilating ducts which were the subject of experiment. Baffle plates concave, straight and convex were tried at the louvers or openings in the ducts. The straight baffle plate was decided to be most satisfactory.

The distribution of the air was found to be a function of (1) the velocity of the air in the trunk flowing past the deflector; (2) the amount of opening of the deflector; (3) the shape of the deflector.

On the whole, the straight deflector proved to be the most satisfactory and was adopted in all subsequent experiments; and for gratings in the proximal end of the trunk nearest to the fan, where the velocities are high and the angle of opening of the deflector small, the straightness and truth of the deflector is of great importance.

As each deflector takes off a portion of the air flowing along a uniform trunk, the velocity of air-flow in the trunk beyond is correspondingly diminished; and since frictional resistance varies as the square of the velocity, there is a very marked reduction in frictional resistance. So important is this effect, that it was found that with a sufficient number of deflectors and gratings distributed along the sides of a uniform trunk of sufficient length, the volume of air delivered was 93 per cent. of the delivery when no trunk at all was connected with the delivery side of the fan, there being, however, a trunk of about the ordinary length and size on the intake side, as would always be the case in a ship.

The deflectors themselves cause no material resistance. There is no difficulty in fixing them so that each gives practically the same delivery of air, a simple formula having been found by means of which this can be done without actual trial. The deflectors remote from the fan, where the velocity and pressure of the air in the trunk are small, require, of course, to be much more widely open than those close to the fan. Suppose the number of deflectors in a trunk is N, then the amount of opening of the Rth deflector will be $\frac{1}{N-R+1}$ multiplied by the width of the trunk, thus, for example, the last must be full open, the last but one-half open, and so on.

In a new ship the deflectors are first adjusted in accordance with the above formula, and then with the fan running under ordinary conditions each delivery opening is examined to see whether the velocity of air current is approximately the same at any portion of the trunk proximal or distal, and the deflectors are adjusted until this has been attained; but once equality of velocity has been secured the deflectors should be permanently fixed, so that unauthorized persons shall not tamper with them and cause too great a draft in one place and a lack of air in another.

In the case of branch pipes it was found best to place a deflector at the junction and so control the delivery through the whole of the gratings on the branch. Each grating on the branch should also have its deflector. It was also found that it made no measurable difference to the amount of air distributed whether the branches came off at right angles or at the usual angle of 30 degrees.

If each grating measures 18 by 6 inches, which appears to be a convenient size, one is required for every two men when 50 cubic feet of air per man per minute is supplied. This, of course, means a considerable number of gratings. On the other hand, the arrangement is simple, inexpensive, and efficient in preventing drafts and distributing air and warmth evenly throughout a compartment. Very favorable reports have been received from all ships so fitted.

As emergency measures, portable electric blowers may be employed, an air-conducting hose being led along the deck, or better, on a level above the deck. The hose may be fenestrated, thus facilitating air distribution.

CHAPTER VIII

HEATING

Heating and ventilation are interdependent and must be considered from several aspects, not the least of which is economy of fuel consumption. Each time the warm air of a room is exchanged for cold air heat units are lost in proportion to the temperature differences.

The air in houses usually is too dry and hot. Such air is not only disagreeable to breathe, but actually parches the respiratory mucosa and irritates it to a degree which exposes the body to infecting organisms which lie upon the epithelium of the mucosa, awaiting a solution of its continuity in order to gain entrance to the unprotected tissues.

Sixty-two to 65°F. is most comfortable temperature for rooms in which relative humidity is seventy. When relative humidity is below this figure a higher temperature is necessary because of the rapid evaporation from the body surface and the consequent sense of chilling. This evaporation decreases to nil as the air approaches saturation with aqueous vapor, hence a proportionately lower temperature is required for comfort.

There are three methods of heat travel:

1. **Radiation.**—By this method heat rays are emitted directly in right lines from the heating body. As one stands in front of an open fire one may be too hot in front and too cold in back by reason of the body's intercepting the radiated rays.

2. **Conduction.**—Heat travelling by conduction follows the continuity of a heated body. A cold poker thrust into the fire soon becomes heated, not alone at the end in the fire, but also at the opposite end which has become hot by conduction.

3. **Convection.**—When heat travels by convection, air about a heated body becomes warm and rises. Air currents thus established are convection currents.

There are seven principal methods of warming air for human comfort:

1. Open fires;

2. Stoves;
3. Gas stoves and fires;
4. Hot air;
5. Hot water;
6. Steam;
7. Electricity.

1. Open Fires.—The most expensive method. Notter and Firth claim that for each pound of coal burned 2600 cubic feet of air pass up the flue. This interchange of air causes most of the heat generated by open fire to escape up the chimney as warmed air. It is estimated (Harrington) that seven-eighths of the heat generated by open-grate fire is lost up the chimney, leaving only one-eighth for heating purposes.

Open grates act by radiation principally, and while they make much dust and do not warm the room well, they are of much value in ventilating the compartments in which they are placed. The best type is one in which fresh air enters from the exterior of the building and comes into the room through a flue at the back of the grate, thus being heated prior to its entry into the room.

2. Stoves.—Stoves placed in the center of the room are a very efficient form of heating. It is claimed that 80 to 90 per cent. of heat generated by this method is utilized.

Stoves tend to parch any organic dust upon them, thus imparting a disagreeable odor to the air in the room.

When red-hot, carbon monoxide may be given off from the surfaces which are so heated. There are various methods of applying the heat of these stoves.

3. Gas Stoves and Fires.—Gas stoves and fires cause considerable atmospheric pollution through combustion and leaky fixtures. They are convenient, clean, and free of dust, but cannot be regarded as an efficient method of heating.

4. Hot Air.—The hot-air-furnace system consists in a central heating apparatus in which air is heated and rises through hot-air ducts to various openings in the spaces to be heated. Usually there is an inlet for cold air which passes into the heating dome (either over heated plates or tubes), thence over a water basin for humidification. These basins are very small and receive too little attention as a rule. This results in too dry air, which has a capacity for carrying much more aqueous vapor, consequently the woodwork and furniture, etc., are dried and damaged. But worse than this is the parching effect upon the skins

and mucous membranes of the occupants of rooms heated by the hot-air method.

5. Hot Water.—Hot water absorbs, carries, and imparts heat well; hence it is very useful for heating buildings. The hot water is contained in pipes leading to heating bodies called radiators in the compartments, and back again to the boiler and furnace.

This system is readily controlled, and where applicable is highly desirable. The air is too dry.

6. Steam Heating.—This method, while tending to over-heat, is commonly used in our country. Steam is generated from a central heating boiler, passes to radiators through steam pipes, through the radiators and back to the boiler (ultimately by way of a hot-water reservoir, thus saving feed water and heat units).

There are two systems of steam heating, viz.:

(*a*) High pressure;

(*b*) Low pressure.

In the former a pressure of 50 pounds per square inch is carried in the pipes and radiators, while in the latter the pressure is carried at 7 to 10 pounds and the pipes are not built to sustain the tension of steam in the so-called high-pressure system.

7. Electricity.—This is a very clean, expensive way of heating, which method may readily be employed in small rooms. Resistance coils are placed in a circuit and by radiation and convection the temperature of the space is raised.

Systems of heating are:

1. Direct;
2. Indirect;
3. Direct-indirect.

1. In the **direct system** the grate, stove, or heating body is directly within and actually heating the room.

2. Indirect System.—In this system the air is warmed by steam or hot water heated in boilers centrally, and delivered to the compartments.

3. Direct-indirect System.—The heating body is within the space to be heated, atmospheric air is drawn into contact with the heating body, heated by it and then passes out into the room.

The advantages of a central heating system are:

1. The service is simpler. Many rooms are provided for with only one furnace;

2. Fuel does not have to be taken to each room, nor does it have to be carried to upper floors;

3. Combustion is easier to supervise and regulate. Heat expenditure is less;

4. Living rooms are kept free of ash, smoke, soot, etc.;

5. Corridors and staircases are more economically heated;

6. An even temperature is possible for the entire house.

The disadvantages are:

1. Initial cost is expensive;

2. Requires a skilled attendant;

3. Mistakes in installation are difficult to rectify;

4. Necessary repairs cause the whole building to be without heat;

5. In the hot-water system there is danger of radiators freezing if the window above them is left open at night.

Heating aboard ships today is essentially by (*a*) steam, or by (*b*) electricity. Formerly it was by hot shot, and later by stoves. On battle ships and larger ships generally living spaces are heated by steam under the high-pressure system, known as the "thermoventilating" system.

Air is taken in by fans through cowls, passes through a *thermo-tank* where it is exposed to steam coils, and after being heated is forced thence into the various living spaces.

This air is not humidified and on the U. S. S. Arkansas I have seen air outside at temperature well below 32°F. taken in, heated to above 120°F., and delivered to living spaces!

The following report on the heating system of the U. S. S. Arkansas was made by me in 1915:

The ventilation, however, cannot be considered independently of the heating system since fresh air is taken in by the blowers, heated (when necessary) by passing over steam coils, and then delivered by blowers through ducts to the various compartments, entering through the McCreery or other terminals. This combined ventilating and heating system is far from satisfactory. During winter weather fresh air is taken in at low temperature and capable even at saturation of carrying a comparatively small amount of water vapor. This air is heated (and expanded), thereby greatly reducing the relative humidity of air finally supplied to the living spaces. For instance, even if air were saturated at 40°F. it would contain 2.86 grains of water (vapor) per cubic foot, and when heated to 70°F., at which temperature the air is capable of holding 8.01 grains per cubic foot, ceteris paribus, this air would have a relative humidity of 36 per cent., whereas the desideratum is about twice that amount, viz., 70 per cent. Expired air is saturated for its temperature, say 98°F., and is carrying about 18.9 grains of water vapor per cubic

foot. The saturation deficit must be supplied by the respiratory mucous tract and much dryness and irritation of the sinuses and respiratory tract result.

Air from a louver in the wardroom country has been observed by me to be delivered at 120°F. dry-bulb (*i.e.*, the thermometer scale would register no higher, but the mercury went the limit), while the wet-bulb thermometer mounted on the same board registered 70°F. Some method of humidification of the air so heated should be devised in order to reduce the headaches, and nasal and bronchial irritation caused by the too-dry air.

The specifications for construction of battle ships' heating plants call for ability of the system to maintain a temperature of 70°F. in the living spaces when temperature of external air is 0°F.; air being delivered full capacity and heated—72,000 cubic feet per minute.

In certain isolated spaces where the ducts of the thermo-tank system cannot be carried radiators are installed. These are of the high-pressure variety and the pipes not uncommonly are led on the deck in the angle between the deck and the vertical bulkheads and are covered by appropriate gratings. Too commonly these pipes and gratings are the sites for accumulation of much dust unless they are carefully tended.

Where long and independent leads of supply and exhaust would be required electric heaters are authorized.

Steam radiators on the new battleships are to supply heat to 50 to 100 cubic feet of air per square foot of radiator surface, depending upon the location and requirements, *e.g.*, bathrooms on a deck already well heated would be allotted 100 cubic feet per square foot of radiator surface, while the chart house, exposed high on the bridge, not surrounded by heated spaces, would be given 50 cubic feet per square foot of radiator surface.

In submarines electric heating is employed and required to maintain a temperature in the boat 15°C. higher than the sea water in which the boat lies.

In presence of possible explosive mixtures of hydrogen and air and of gasoline it is desirable to have no open flame to vitiate air or cause explosion. Hence electricity lends itself well to the purpose of heating submarines.

Finally any system of heating must be operated intelligently. If it is designed to operate with certain hatches closed or certain doors opened, it scarcely can be expected that it will operate successfully with a reversal of these conditions.

The thermo-tank system has certain objectionable features. It is a

system which combines heating and ventilation. Air is warmed and dried but not humidified.

The system is difficult to control, since one compartment may be too hot while another is too cold. Cutting off heat from the former renders the latter still less comfortable. Until independent heating and aeration can be accomplished conditions will remain unsatisfactory and insanitary.

CHAPTER IX

WATER

Water is a fluid composed of two parts hydrogen and one part oxygen, and probably exists in a pure state only as a laboratory curiosity.

Physical Properties

Pure water is transparent, odorless, tasteless, and almost colorless at ordinary temperature and pressure. It is not absolutely colorless. It has a slightly bluish tinge under normal conditions.

Water boils at 212°F. or 100°C., and freezes at 32°F. or 0°C. at standard barometric pressure, and is almost incompressible.

At the freezing point water rapidly expands and when frozen solid has increased by about one-eleventh of its original volume.

The temperature at which water boils varies directly with atmospheric pressure, falling as pressure is diminished.

Water has great power as a solvent and in nature its contact with various chemicals forms acid or alkaline solutions which are constantly changing—slowly, but no less surely—the broad face of Nature.

Solution of gases is a property of water and it is to this property, in part, that the palatability of potable water is due, viz., the aeration, or absorption of atmospheric air.

The gaseous content of water is driven off by boiling which produces a flat, or almost "oily" taste. Boiled water readily may be restored to its original state of potability by agitation in the air.

Man's Needs.—Man needs daily a half ounce of water per pound of body weight for internal use. Obviously the needs vary with his habits and work.

Water constitutes more than two-thirds by weight of the human body, even the teeth containing 10 per cent. water; and when it is remembered that man must depend upon water for alimentation, and that the tissues are constantly being bathed in a fluid, the chief

constituent of which is water, it will be realized that next to air, water is necessary to human existence. A man weighing 150 pounds has a water content weighing 100 pounds. The loss of one-tenth of this fluid content is dangerous, *i.e.*, 10 pounds or about 1 gallon.

Without water as food or drink it is doubtful if the strongest man can survive for a period of five days. The male adult consumes as food and drink from 60 to 100 fluid ounces daily. Women require somewhat less. Marching men require 1 quart of water for every 7 miles covered by them, and even more in hot weather.

The amount of water ingested will vary with the diet, work, season, temperature, condition of the alimentary tract, psychic or emotional state, hygrometric state of the atmosphere, and certain diseases.

The sum total of water which the inhabitants of a city need *to drink* in no way represents the daily requirements of that community. Much is needed for baths, sewerage, laundry, and domestic animals, as well as the industries, etc. In cities it is estimated that if possible a minimum of 50 gallons per day per capita should be allowed. Pittsburgh has 250 gallons.

For one reason or another the per capita supply of water consumed by many cities is smaller than the above-mentioned minimum; *e.g.*, Berlin is said to use 15½ gallons per capita, Vienna 22, London 28¼, Paris 44, Glasgow 50.

Hospitals require a much larger supply of fresh water. The per capita supply should be unlimited. Where unlimited supply is not available the per capita allowance should be as little below 100 gallons as the supply will permit.

Water Aboard Ship.—On board ship distilled water is supplied for drinking, cooking, and usually for bath and laundry purposes. This water is often distilled from fresh feed water taken aboard from hydrants at the dock or from water boats. Manifestly the purity of this water may be questioned. Distillation renders it pure.

In time of war, when coal consumption must be considered, distillation may not be practised. If the water cannot be distilled it should be chlorinated.

Chlorination should be done as soon as the water is taken aboard and repeated just before the water is used for drinking. This would prevent the result of possible bacterial infection by an enemy. The second chlorination probably would be unnecessary if the drinking water tanks are under proper bacteriological supervision.

When steaming at sea the fresh water supply must come from "over the side," *i.e.*, salt water is distilled.

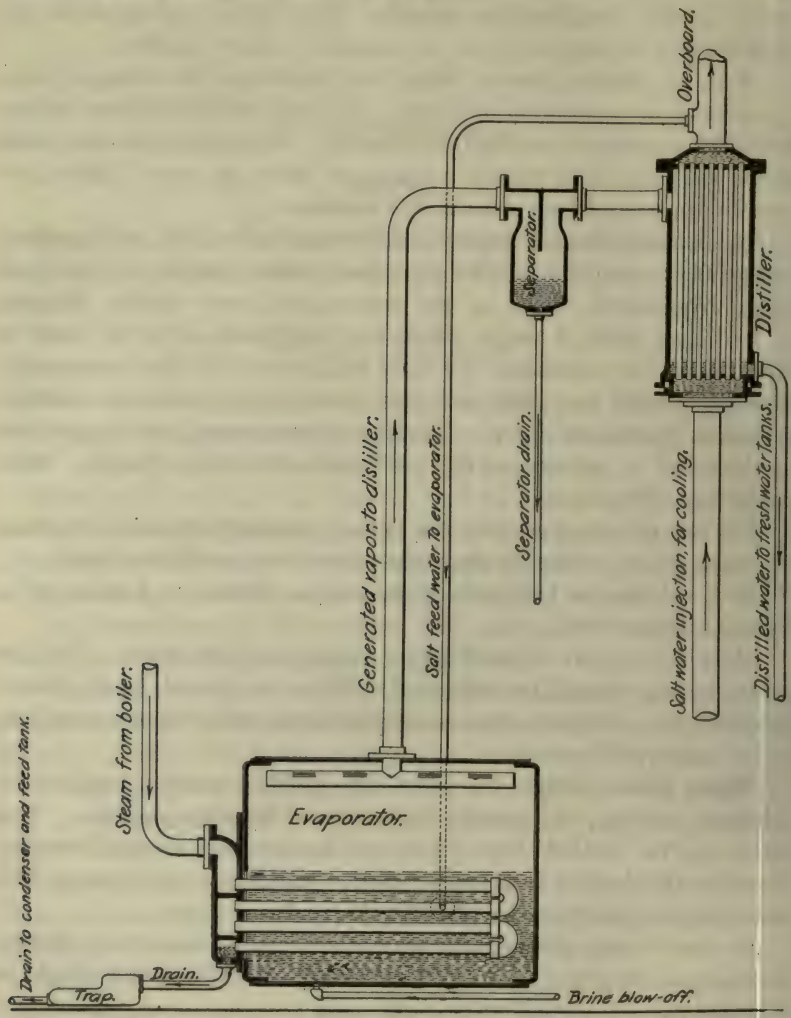


FIG. 25.—A diagram showing general plan of the apparatus used for distilling salt water on board ship. The salt water is evaporated by means of steam coils which pass through it. The vapor is then distilled, being cooled by passing around pipes in which cold salt water is circulating. (*Gatewood.*)

At sea the distillate is pure except that the water may taste of chlorine (as salt) or of oil from the machinery (as the result of leaky tubes in evaporators or condensers).

Sudden increase in saline content of distillate should never be ignored. The cause is frequently a leaky tube. If the sea water be taken from well off shore, *e.g.*, 100 miles, such a leak means little except that the drinking water shows more salt than usual. This is in such small quantity that it is not apt to do more than render the water a little less palatable. Such a leak, however, occurring when the ship is lying in a sewage polluted harbor, is a much more serious matter, as the health of the personnel may be menaced.

FIG. 26.—Showing mess tables. Bread may be seen lying upon bare wood which may not have been thoroughly dry.

There is no evidence that pure distilled water is harmful to man. Some have claimed it is. Experience has proved their claim untrue.

A system of salt water is distributed over ships for flushing closets, baths, in pantries, fire mains, etc. In harbors this may be a grave menace, as is apt to be the washing of decks with such water. Especially is this true of washing *mess tables*. Tables wetted down seldom have time to dry thoroughly before they are needed for the next meal.

As they are not covered, it is easy to see that the table surface, moist with polluted water, is apt to infect a slice of bread which will absorb moisture and infection like a blotter.

Salt water in a pantry must be regarded as a menace. Careless servants may rinse dishes in harbor water badly contaminated with sewage. Likewise in baths care must be taken that salt water is not used in harbors.

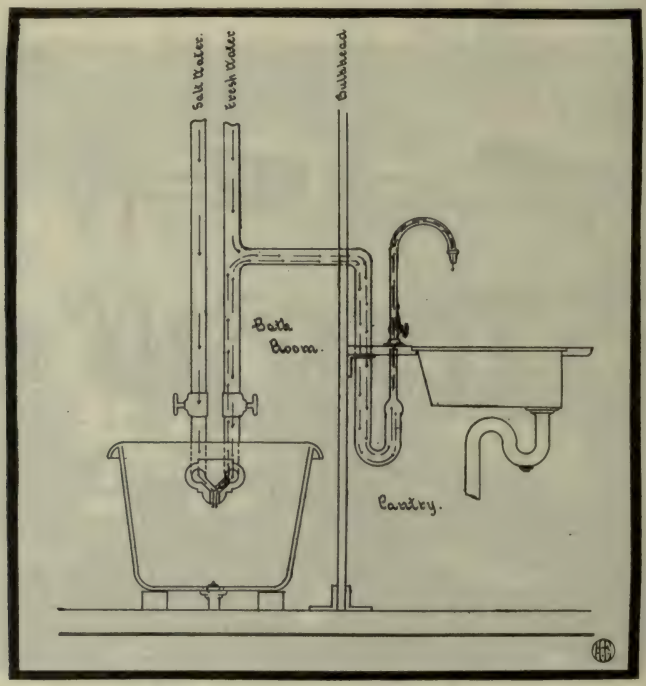


FIG. 27.—A sketch showing how fresh water may be contaminated by salt water if the two systems discharge at a common opening. (*Gatewood.*)

Fabrics, decks, etc., thoroughly wetted in salt water seldom if ever become dry thereafter unless they are thoroughly washed in fresh water, for the salt deposited in the fabric or wood, being hygroscopic, never parts wholly with its water in ordinary conditions until the salt is washed out.

Bathing and scrubbing in water from over the side of the ship should be discouraged, except at sea where water is probably free of

pollution if taken from beyond the sphere of influence of the ship's sewage pipes.

Distilled water is highly desirable, if expensive, for laundry purposes. If the water distilled from the sea contains considerable chloride or sulphate content it will prove unsatisfactory, being too "hard" for laundry use.

Storage of Water on Ships.—When water is distilled or is received for storage on board ship it is placed in large steel compartments or tanks which are entered by manholes. The water enters the tank through pipes from pumps and leaves the tank through discharge pipes for distribution to the several smaller gravity tanks, which give "head" or pressure to the water as it goes to the fixtures.

From this it will be seen that distilled water goes directly from the distilling plant into the storage tanks, remains there for storage, cooling and aeration, and thence goes to the fixtures for drinking and washing purposes.

In this process there is no opportunity for infection as the water is not exposed from the time it leaves the distillers until it reaches the fixtures.

The tanks are coated on the interior with bitumastic to prevent rusting.

After heavy weather in which the water in the tanks becomes greatly agitated iron rust is apt to appear in suspension, but this is not harmful.

When it becomes necessary to clean the tanks they should be entered through manholes on the sides rather than on the top of the tank. In this way dust collecting on top of the tank is not likely to gain entrance.

Carriers of disease should not be permitted to enter the tanks for purposes of cleaning, and clean rubber boots and fresh clean clothing should be worn by all entering the tanks for work.

After the tanks have been thoroughly scrubbed with soap and water and rinsed with disinfecting solution if necessary, they should be rinsed with fresh water. A steam hose should then be led into the tank in order to steam it thoroughly before permitting the entrance of freshly distilled water.

Unless the medical officer exercises careful supervision over the cleaning of the tanks they readily may become infected.

Water enters these tanks from the distillers at a temperature

approximating 90° to 100°F. in temperate climates and even so much as 180°F. in the tropics. Obviously many factors influence the temperature of the distillate, but in the tropics and probably a fair proportion of the time in temperate climates, the distillate will enter the tanks at a temperature almost equal to that at which milk is pasteurized.

When water from on shore is introduced directly into the drinking tanks (and this should not be done if it can be avoided) it often happens that the confinement of the water in a warm temperature between decks results in decomposition of organic matter with a very foul odor resulting. At times water is taken from streams grossly polluted with organic matter, as for instance when salmon are running. The fish impelled by spawning instinct swim from salt water up stream into fresh water, generally so far as the first insurmountable waterfall. They go in schools and at times are so numerous that the water is seriously polluted by the decomposing flesh of injured fish and by their excretions.

I have seen water taken on board ship from a stream in Alaska in which salmon were running. This water was taken contrary to advice of medical officer, as it seemed expedient to get fresh water at this place. Within forty-eight hours the odor of decomposition coming from the water tanks was so great as to render the water disgusting. It could not be drunk and the foul odor pervaded the various compartments in the vicinage of the tanks. It was necessary to empty the tanks and thoroughly cleanse them before pure water could be put into them again.

Sea Water.—Sea water contains proportions of saline constituents varying in concentration with the portion of the globe washed by that part of the sea under examination.

The Atlantic Ocean contains about 35,900 parts of salt per million, the salts and proportions being as follows:

Sodium chloride	28,032 parts per million
Potassium chloride	791 parts per million
Magnesium chloride	3,341 parts per million
Magnesium sulphate	2,191 parts per million
Calcium sulphate	1,412 parts per million
Magnesium bromide	75 parts per million
Calcium carbonate	50 parts per million
Ferrous carbonate	5 parts per million
Magnesium nitrate	2 parts per million

Ammonium chloride and traces of magnesium carbonate, lithium chloride, and silica are found.

It will be observed from the above that sea water is permanently hard.

Usable water should be not over 3.5 degrees hardness (Clark scale or 50 parts per million) while sea water is 431 degrees hardness (Clark scale or 6157 parts per million).

Water on Shore.—As naval forces often operate ashore, water on shore should be considered.

For convenience of description water may be classified into the following varieties, viz.:

1. Meteoric water—rain, snow, hail, sleet, frost, dew.
2. Surface water—rivers, lakes, ponds.
3. Ground water—subsoil water.
4. Deep-well water—artesian water.

1. **Meteoric water or rain,** etc., is the chief source of fresh water supply. Surface, ground and artesian waters are all modifications by environment of meteoric water.

Owing to its property of gas absorption rain water will absorb many of the gases which pollute the air during its precipitation, consequently it may be said that the purity of meteoric water varies with the purity of the atmosphere through which it falls.

Therefore, if the air be polluted with human excreta and exhalation; with gases of decomposition of animal and vegetable matter; with dust or bacteria; or the mechanical or chemical products of the industrial activities; the rain water may be expected to give evidence thereof.

It is stated that rain water absorbs 25 c.c. of gases per liter from the air. This volume is composed of 34 per cent. oxygen, 64 per cent. nitrogen and 2 per cent. carbon dioxide.

Traces of ammonia may be found and this will increase as the rain cloud moves from country or sea toward urban centers where the air contains nitrites, nitrous and nitric acids, sulphurous acid, soot, bacteria, etc.

Near the sea meteoric water is apt to contain salts from the sea itself.

When meteoric water reaches the earth some of it gradually finds its way into rivers, streams, lakes, etc., and becomes the **surface water** of our classification; some percolates until it reaches the first impermeable stratum and becomes **subsoil** or ground water; while some, falling between outcroppings of impermeable strata, percolates to and runs along the deeper impermeable stratum and gives to us **artesian** water; and lastly some of this rain water is evaporated, as result of winds and temperature, into the atmosphere, again to make up its saturation

deficit. It is estimated that about 50 per cent. of meteoric water thus is returned to the amosphere.

There is a marked variation in annual rainfall in different parts of the world, from the desert to the places where rainfall is almost unbelievably great, amounting to 600 or 800 inches in Assam.

2. **Surface water** is chiefly composed of the rainwash of the earth's surface and of objects resting upon it.

Surface waters may be standing or flowing, depending upon natural or artificial barriers, consequently it is found in lakes, ponds, streams, and rivers.

It is evident that surface water will take its character from the watershed upon which it falls and runs; hence it may be pure or polluted; alkaline or acid; clear or turbid; odorless or foul-smelling; colorless or colored; may contain or be free of animal parasites which infect man; may or may not contain inorganic salts; and may or may not contain pathogenic bacteria.

Its content, hence its purity, will vary with many factors, *e.g.*, geologic formation, proximity to human habitation, freezing and thawing, rainy or dry season, sewage output from cities, etc.

River water contains considerable matter in suspension, and in clayey countries, some of this suspended matter is ultramicroscopic.

3. **Ground Water.**—Ground or subsoil water may be defined as that part of meteoric water which has percolated through the superficial strata of the earth's surface until it has reached a clayey or other impermeable stratum.

The level of this ground water will vary with the thickness and inclination of permeable strata, barometric pressure, and degree of precipitation.

Just as with surface water, this water is derived from meteoric water, and as ground water percolates its depth will vary from a fraction of an inch to hundreds of feet, depending upon the above-mentioned conditions.

Ground water is apt to contain much less suspended matter than surface water, as matter in suspension will have been removed in good part by the process of percolation through the soil—natural filtration.

In exchange for its suspended matter this water takes into solution a part of the soluble mineral salts contained in the ground through which it passes.

Ground water may be obtained anywhere by digging to sufficient

depth. It is by capillarity that this water keeps moist the superficial layers of the soil.

The more water pumped from a shallow well, the greater the distance ground water must come to replace the water removed, and hence the probability of pollution is increased in proportion to demands upon the well.

Ground water is in constant motion toward an outlet somewhere, just as is a river (not rapidly because the movement is a sort of percolation process), and like the river its level may rise and fall depending upon the water supply.

Its rate of movement is 15 to 250 feet in twenty-four hours.

4. Deep Ground or Artesian Water.—Deep ground or artesian water is that which is found at a very great depth, having made its way between deep and impermeable strata. The artesian well is the result of tapping this water at great depth.

Depending upon the "head" or source of the subterranean water will be its level. At times the difference of level between the site of the well and of the source is great. If the source be much higher than the well the water may emerge from it with such force as to throw it into the air and obviate the necessity for the employment of a pump.

Artesian water is free of organic pollution, and on the other hand contains soluble substances derived from the geological strata with which the water has come into contact.

Characteristics of Water.—Rain water is apt to be pure, *i.e.*, pathogenic germs are not present, and unless near the sea is apt to contain no inorganic salts. It is "soft."

Surface, ground, and artesian waters are apt to contain soluble substances from the geological strata through or over which they pass. If water contains much lime or magnesia salts it is spoken of as "hard." This is because of the difficulty of washing with it, for soap refuses to lather freely in the presence of these salts, but precipitates instead; *e.g.*, each grain $CaCO_3$ in a hard water must be satisfied with 8 grains of soap before lather will form.

There are **two kinds of hardness** of water, **temporary** and **permanent.**

Temporary hardness is due to bicarbonates of calcium and magnesium kept in solution by CO_2 contained in the water. Boiling drives off the CO_2 which precipitates the insoluble carbonates, so that some hard water will be soft and usable after boiling has removed its "temporary hardness." The carbonates are deposited on the bottom of the boiler.

If, however, the hardness is due to the presence of fixed salts of calcium and magnesium, the hardness is not removable by boiling and is called **permanent hardness** in contradistinction to temporary or removable hardness which disappears upon boiling.

Rain water and all waters which do not contain the salts of the alkaline earths are called soft waters, lather freely and may be used with comfort if they are otherwise pure.

Pollution of Water.—Water may be polluted by various contaminants which may be:

1. Chemical and in solution;
2. Mechanical:
   (*a*) Organic:
      1. Animal, living or dead;
      2. Vegetable, living or dead;
   (*b*) Inorganic and in suspension.

Chemical pollution may be organic or inorganic, it may be gaseous, in solution or in suspension.

Chemical pollution will necessarily vary with the character of the atmosphere through which the water has fallen; with the character of industries; with the surfaces upon which it has fallen; with the geological strata through which it has been percolated; with the place and method of storing it; with the character of the pipes through which it may be distributed; and with the character of the containers in which it may be held for temporary use within the habitations.

Mechanical pollution may be either microscopic or macroscopic; may be living or dead animal or vegetable matter; or may contain particles of inorganic matter in suspension, *e.g.*, clay, silicates, etc.

Animal pollution of water may of course vary from unicellular to vertebrate forms, living or dead.

A large number of animal forms normally are found in water, and so far as we know are productive of no ill-effect upon man. Some of the more highly organized animals are occasionally found, *e.g.*, *Cyclops tenucornis*, *Daphnia*, and some of the nematodes, as *distomum*, etc.

Again the ova of the parasitic animals which infect the human intestine are found.

Vegetable contamination consists of many of the chlorophyl-bearing algæ; diatomacæ, etc. But more important to us are the non-chlorophyl-bearing plants, *e.g.*, bacteria, cladothrix, leptothrix.

The presence of the various forms of animal or vegetable life in

water indicates in general terms the presence of food materials necessary to their existence, but not necessarily organic or harmful to man.

Potable Water

Appearance.—A pure water should be clear, transparent, limpid, colorless (slightly bluish if viewed against a white surface and in a deep vessel) and sparkling if it contains much CO_2.

A colorless, beautiful water may contain harmful inorganic substances, ova of animal parasites or pathogenic bacteria in dangerous proportions.

A potable water may possess a certain amount of turbidity, more pronounced after rains, which may settle, or be precipitated by chemical means.

Again a potable water may have a brownish color due to the presence of the compounds of iron or organic matter.

Generally speaking, water takes its color from vegetable substances with which surface waters come in contact. *Colorlessness does not indicate purity.*

Reaction.—Water containing CO_2 may be faintly acid, but most drinking waters are alkaline due to the presence of small amounts of alkaline carbonates.

Rain waters are often slightly acid due to the presence in the air of products of combustion.

Mineral acids are found in streams in mining districts.

Odor.—Ordinarily no odor is detected upon examination of pure water which is fresh.

Putrefactive changes may be present in water due to action of bacteria upon sulphates giving odor of sulphuretted hydrogen.

Certain animal and vegetable forms may be present in potable water and impart to it a noticeable odor, which will be more pronounced upon heating.

E.g., the Boston water supply was in 1878 found to have a peculiar odor due to the decomposition of fresh water sponge growth.

Taste.—Pure water has no taste except from the gases which it may absorb.

The various salts may be present in large proportion before they may be detected by taste. Sodium chloride must be present in excess of 60 grains per gallon before it can be tasted.

It must be repeated that a water may be clear, odorless, and tasteless—*yet very dangerous.*

Ammonia, chlorides, nitrates, and nitrites in themselves are not dangerous to man, but they are indices of probable contamination.

They perform the same function in relation to water that CO_2 does for air.

Their presence indicates pollution, present or past, and must be regarded with suspicion.

Sources of Water.—Man obtains water from several sources, chief among which are:

1. Rain water in cisterns:
   Underground;
   Above ground;
2. Rivers, lakes, ponds, and springs;
3. Wells;
4. Artesian wells;
5. Distillation.

Rain Water.—In sections where surface or ground waters are not available for water supply, rain water may be caught and preserved for use in cisterns.

The water is usually caught upon the roofs of houses which are provided with gutters and down spouts for conducting it.

The form of the roof matters little in estimating its water collecting capacity, for the actual superficial area occupied by the house, and not the superficial area of the roof will determine the amount of water caught during a given rainfall.

A rainfall of 1 inch upon a square yard gives 5.61 gallons (gallon = 231 cubic inches).

A rainfall of 1 inch upon a house 20 feet square, equals about 250 gallons.

Rain water should be collected only after rain has been falling for some time in order, (1) to wash thoroughly the roof, and (2) that the lower air strata may be washed of dust and bacterial content.

Cisterns in which rain water is preserved should be steened with stone, brick, or concrete, and cement mortar if underground, and should be water-tight. In no case should lead, copper, zinc, iron, etc., be used for lining, as the CO_2 in the water attacks these metals in a measure. Lime mortar, too, is apt to give salts of lime to the water which make it hard and impart a disagreeable taste.

Cisterns should be provided with overflow pipes which discharge into the air—not into a sewer or house drain.

Cisterns should be carefully covered to prevent the entrance of dust, insects, and small animals.

All openings discharging into the air should be thoroughly screened with copper or bronze wire, 18 strands to the linear inch, to prevent access of mosquitoes and small insects.

Not infrequently water from roofs is passed through sand filters before it is permitted to enter the cistern.

The integrity of the cistern is of vital importance and the cistern should be frequently inspected to detect the presence of possible cracks.

It seems needless to say that all the openings above ground should be of such height and nature as to prevent the inflow of uncontrolled water.

In some localities the cisterns are made of brick, stone, iron, or wood and are *above ground*. While not so liable to pollution by seepage these cisterns are apt to afford in summer a warmer water supply than would the *underground cistern*.

Wooden cisterns are undesirable, especially in hot countries, as the wood decays rapidly and requires constant repairing.

Surface Water.—Rivers, lakes, ponds, and springs.

As a spring emerges from the earth in an uninhabited area we are apt to find a very pure drinking water.

It is ground water as it emerges, but immediately becomes surface water as it flows away to form perhaps the headwaters of a large river.

Upon its emergence the waters may be hard or soft, depending for its character upon the geological strata with which it has been in contact.

This fresh spring water contains more inorganic than organic substances—the animal and vegetable life having been in part filtered from it in the process of percolation.

As the water flows upon the surface receiving accessions from other streams, surface wash from rain water, and the sewage from towns and cities upon its banks, it becomes more polluted as the population grows denser.

In general rivers are composed chiefly of rain water, or surface wash. In its onward flow this water receives a large amount of low animal and vegetable life, sewage, drainage, and pollution resulting from the industries.

In such a water the purifying action of the sun is pronounced and is aided by agitation of the water in its rippling over a shallow rough bottom.

This action of the sun has little effect upon organisms in presence of turbidity.

In streams near large cities the bacterial action may be very great and in its effort to oxidize the sewage pollution so much of the oxygen in the water may be consumed that the water will not support the life of fish, *e.g.*, the Thames at London and the Seine at Paris.

The water in surface streams is more turbid during rainy weather than during dry weather, due to the larger suspended content which is washed from the watersheds.

Where large water supply is obtained from rivers and streams it usually becomes necessary to dam them and thus to convert them into large reservoirs through which all or a part of the river flows. It becomes necessary at times to purchase large tracts of land about these reservoirs, whether formed by dams, small lakes, or ponds, in order that uninhabited watersheds may be secured.

Wells.—In almost any locality one may obtain water by boring to sufficient depth. Such an artificial opening of the superficial strata of the earth down to water level is called a well.

A well less than 50 feet deep is a "shallow well" and a well over 100 feet deep is called a "deep well."

The well may be either (1) a "dug well," or (2) a tubular or driven well.

1. A **dug well** is of large caliber, and frequently is imperfectly steened. The dug well has a large mouth through which it is quite possible for contaminants to enter, especially as such wells are too frequently drawn from by means of a windlass and bucket, which latter is subjected to constant handling by hands not always clean. Shallow wells are far more apt to be polluted on this account.

Wells are said to drain a segment of the earth the shape of an inverted cone, the base having a diameter of four times the depth of the well. Water making its way through the ground in the vicinage of a dug well, *i.e.*, within the supply area of a dug well, tends constantly toward the well because of the diminished lateral pressure.

2. **Tubular or driven wells** are obtained by forcing a drill through the earth until a water-bearing stratum is reached, and then driving

in a galvanized iron tube from the surface to the bottom, after which a pump is attached to the tube.

It will be evident that pollution from above through the pump is not apt to occur, and as the sections of the tube, which is about 4 inches in diameter, are screwed into each other as they are driven down, surface contamination is less probable than in a dug well.

As driven wells are usually wells of greater depth than the standard set for shallow wells, it would appear that the water from driven wells is probably pure *unless* perchance some subterranean fissure exists through which surface contamination could occur.

Much stress is laid upon the bacteriological pollution of well water by seepage or percolation from cess pools through the earth into the well.

Such pollution must be less frequent than is commonly supposed. When one considers the filtering power normal to the earth's strata, the distance through which fecal matter would have to pass in most cases, and the infrequency with which *Bacillus typhosus* has been isolated in well water, it would seem that we should look elsewhere for the source of infection. The *possibility* of such pollution is freely admitted, but it seems probable that only the filtered sewage would reach the well, the solids and bacterial growth being held back by the strata of earth unless fissures permit direct communication between the well and the cess pool. This may happen in limestone formations.

The possibility of such direct communication should always be borne in mind, and the possibility of the existence of an old and forgotten pipe communication, fissures in the earth, excavation for new construction, or the holes or burrows of moles or rats in search of water should be remembered.

Filtration removes 99½ per cent. of bacteria from water; so, as stated above, it seems very probable that bacterial pollution of a well through the earth is relatively infrequent.

Artesian wells are usually very deep, bored wells, having pure water which is frequently under pressure so great that it flows spontaneously from the tube without pumping. Although this water is quite pure it is usually very hard, having absorbed the soluble salts of magnesium and calcium, as well as other alkaline salts from the strata through and along which the water has passed, and is generally poorly aerated, hence loses some of the palatability which good water should possess.

Water Analysis.—The potability of a given water can be determined only after a careful analysis of the water under standard bacteriological and chemical conditions, and a careful survey of source and a consideration of possible pollution.

Appearance, odor, taste, etc., may tell much, but not enough. Of prime importance is examination of the source of the water, as to its probable contamination by human excreta, for as a general rule the infections which affect man are propagated by man.

Bacteriological analysis is of far more importance than the chemical. The value of the latter should not be underestimated, but the bacteriological analysis demonstrates the presence or absence of pathogenic organisms, and chemical analysis can only offer presumptive evidence concerning the occurrence of such organisms in water.

1. The **chemical analysis** of a water is a great aid in determining the pollution of a water supply, but the findings frequently vary so much and within a limit of permissible impurity, if the percentage of the ingredient be alone considered, that the result of such examination should not be regarded as evidence of purity or contamination unless a comparison is made between these results and the findings in the examination of a pure water in the same neighborhood.

In the chemical examination the color, odor, turbidity and sediment should be noted, and total solids, chlorine, free ammonia, albuminoid ammonia, nitrites, nitrates, oxygen consuming power, hardness, and presence of poisonous metals are determined.

In practical work the estimations of total solids, free ammonia and albuminoid ammonia are, despite their great value, not practical aboard ship, because the necessary apparatus is not available, and the motion of the ship would interfere with the delicate manipulation of the apparatus.

The estimation of hardness is not of vital hygienic value, although it is desirable, of industrial importance, and should be made.

Estimation of chlorine, nitrites, nitrates, and oxygen consuming power constitute the practicable chemical examination of water under average conditions aboard ship.

Decomposing animal matter is resolved into its elements. Of these nitrogen combining with hydrogen forms first ammonia. Consequently the presence of "free ammonia" indicates pollution in early stages of reduction, *e.g.*, raw sewage. Later as the water percolates through the soil it takes up oxygen and gradually becomes nitrous

acid and nitric acid—the final stage. Nitrites are evidence then of the intermediate stage of reduction and nitrates indicate the final stage. Nitrites and nitrates plus chlorine strongly indicate sewage contamination.

Decomposing vegetable matter yields very little nitrogen; plants utilize nitrites and nitrates as food; hence water polluted by decomposing vegetable matter shows a very small content of nitrites and nitrates, or none at all. In other words, increase of chlorine, nitrous acid (as nitrites), and nitric acid (as nitrates) indicates pollution from animal sources most frequently, but not always.

Skill in laboratory methods and a knowledge acquired from study of analyses of specimens of water are necessary for the correct interpretation of results in a given case.

Bacteriological Analysis.—The bacteriological analysis of water demonstrates the presence or absence of pathogenic organisms in the specimen examined, and affords more than the presumptive evidence offered by the chemical examination.

The presence of *B. coli*, or of other intestinal organisms indicates sewage pollution.

Increase of chlorides, nitrites and nitrates *may* indicate sewage pollution. It may not.

The following instructions for the chemical and bacteriological examination of water are quoted from the official "Memoranda to Accompany the Naval Test Case and Microscopical Outfit," supplied to the Medical Department, U. S. Navy:

Bacteriological Analysis

1. The three principal points to consider are:

(*a*) Number of bacteria per cubic centimeter.

(*b*) Nature of bacteria (whether developing at 37.5°C.).

(*c*) As to presence of special organisms (*B. coli*, *B. typhosus*, streptococci, *Sp. choleræ asiaticæ*).

2. In collecting water attend to the following points:

(*a*) Bottles (from 25 to 100 c.c. capacity) should be sterilized (either by heat or by rinsing with a little H_2SO_4 and subsequently washing thoroughly with the suspected water before collecting). If to be transferred, pack in ice to prevent bacteriological development. (Frankland states that a count of 1000 per cubic centimeter became 6000 in six hours and 48,000 in forty-eight hours.)

(*b*) If collecting from city water supply be sure not to take from a cistern, but always direct from mains. Let the water from tap run a few minutes before collect-

ing. If from pond, stream, or cistern, be sure that the water comes from at least 12 inches below surface (avoidance of surface scum, etc.).

(*c*) In relatively pure waters, as from springs, bacteria multiply rapidly during first few days; in impure water, however, multiplication is slow.

Quantitative Bacteriological Examination.—(A) Deliver definite quantities of the water to be examined into tubes of liquefied gelatin or agar and plate out the same in a series of Petri dishes.

A more practical method is to deliver the water from the graduated pipette into the empty sterile dish. The water should be deposited in the center of the plate and the melted gelatin or agar poured directly on the water and then carefully tilted to and fro to mix the water and the medium. One set of plates should be of gelatin and incubated at room temperature; a similar set should be of lactose litmus agar and incubated at 38°C. If the water is highly contaminated it is necessary to dilute it; thus, with river water, which may contain from 2000 to 10,000 bacteria per cubic centimeter, a dilution of 1 to 100 would be desirable.

Ordinarily it will be sufficient to deliver from a sterile graduated pipette 0.2, 0.3, and 0.5 c.c. of the water in each of two sets of plates, one set for gelatin, the other for agar.

When gelatin is not at hand or convenient to work with, the gelatin plates may be replaced by others of lactose litmus agar for incubation at room temperature. After twenty-four hours at 38°C. or forty-eight hours at 20°C. the count should be made.

Example.—Forty colonies were counted on the gelatin plate containing 0.2 c.c. ($\frac{1}{5}$) of the water. The number of organisms would be 200 per cubic centimeter. Ten colonies were counted on the agar plate containing 0.2 c.c. and incubated at 38°C. Number of bacteria developing at body temperature equals 50 per cubic centimeter.

There is no strict standard as to the number of bacteria a water should contain per cubic centimeter. Koch's standard of 100 colonies per cubic centimeter is generally given. It is by the qualitative rather than the quantitative analysis that one should judge a water.

If there should be very many colonies on a plate the surface can be marked off into segments with a blue pencil. If very numerous, cut out of a piece of paper a space equal to 1 square centimeter. By counting the number of colonies inclosed in this space at different parts of the plate we can strike an average for each space of 1 square centimeter. To find the number of such spaces contained in the plate, multiply the square of the radius of the plate by 3.1416; then multiply this number by the average per square centimeter and we have the total number of colonies on the plate. This is the principle of the Jeffers disk.

The relative proportion between the bacterial count at 20°C. and that at 38°C. is of great importance from a qualitative standpoint, as will be seen later.

(B) Deliver into a series of Durham fermentation tubes containing glucose bouillon, and into another series containing lactose bouillon, varying definite amounts of the water to be examined. In specimens showing the presence of gas in both glucose and lactose bouillon the evidence is presumptive that the colon bacillus is present. For the positive demonstration plates must be made from such tubes as show gas.

It is sufficient to deliver from graduated pipettes in each series quantities of water varying in amount from 0.1 c.c. to 10 c.c. In our laboratory we inoculate with 0.1 c.c., 0.2 c.c., 0.5 c.c., 1 c.c., and 10 c.c. of the suspected water. If the 0.1 c.c. tubes show gas we have reason to assume that the water contained at least 10 colon bacilli per cubic centimeter. If only the 10 c.c. tubes showed gas—those with less amounts not having gas—we would be in a position to state that the water contained the colon bacillus in quantities of 10 c.c., but not in quantities of 1 c.c. or less. Many authorities regard water as suspicious only when the colon bacillus is present in quantities of 10 c.c. or less, waters of good quality frequently showing the presence of the colon bacillus in quantities of 100 to 500 c.c.

It is generally accepted that if a water shows the presence of the colon bacillus in quantities of 1 c.c. or less it should be regarded as suspicious.

At the present time the medium that gives the least source of error in carrying out the quantitative presumptive tests is the lactose bile. It is made by adding 1 per cent. of lactose and 1 per cent. of peptone to ox bile, and fermentation tubes of the media showing gas may be considered as very probably containing the colon bacillus. The percentage of error with this method is reported to be only 11 per cent., while with glucose fermentation tubes the error is more than 50 per cent. Gas formation is usually shown in forty-eight hours, but it is advisable to continue the incubation for seventy-two hours. These presumptive tests are chiefly of value in highly contaminated waters. Even with this method plates should be made.

(*c*) As the colon and sewage streptococci ferment lactose with the production of acid and hence produce pink colonies on lactose litmus agar, much information can be obtained from the proportion existing between the number of pink colonies and those not having such a color. Waters of fair degree of purity rarely give any pink colonies.

Qualitative Bacteriological Examination.—*General Considerations.*—In some countries the proportion of liquefying to non-liquefying colonies on gelatin plates is considered of importance. Certain sewage organisms belonging to the proteus and cloaca group liquefy gelatin; consequently, if the proportion of liquefying to non-liquefying be greater than as 1 to 10, the water is considered suspicious. The test is not considered by American authorities as of any particular value.

The American Public Health Association recognizes the importance of the information obtained from a comparison of the number of organisms developing at 38°C. and those developing at 20°C. Bacteria whose normal habitat is the intestinal canal naturally develop well at body temperature, while normal water bacteria prefer the average temperature of the water in rivers and lakes. Consequently when the number of organisms developing at 38°C. at all approximates the number developing at 20°C., there is a strong suspicion that sewage organisms may be present. Normal waters give proportions of 1 to 25 or 1 to 50, while in sewage-contaminated waters the proportion may be as 1 to 4 or less.

In addition, the appearance of pink colonies on the lactose litmus agar is of great assistance in judging a water. Both sewage streptococci and the colon bacillus give pink colonies—those of the streptococci are smaller and more vermilion in color. Microscopic examination will differentiate the cocci from the bacilli. It is well to bear in mind that the pink colonies after twenty-four hours may turn blue

(in forty-eight hours) from the development of ammonia and amines. Consequently the lactose litmus agar plates should be studied after twenty-four hours.

A good water supply will rarely show a pink colony, while in a sewage-contaminated one the pink colonies will probably predominate.

The diagnostic characteristics considered important by the American authorities in reporting the colon bacillus (recently designated as excretal colon bacillus) are:

(*a*) Typical morphology, nonsporing bacillus, relatively small and often quite thick.

(*b*) Motility in young broth cultures. (This is at times unsatisfactory, as some strains of the colon bacillus do not show it even in young bouillon cultures.)

(*c*) Gas formula in dextrose broth. Of about 50 per cent. of gas produced, one-third should be absorbed by a 2 per cent. solution of sodium hydrate (CO_2), the remaining gas being hydrogen. Later views indicate that the gas formula is exceedingly variable and should not be depended upon. To carry out this test one fills the bulb of a fermentation tube with the caustic-soda solution, holding the thumb over the opening or closing it with a rubber stopper; the bouillon culture and the soda solution are mixed by tilting the fermentation tube to and fro. The total amount of gas is first recorded and then that remaining after the CO_2 has been absorbed is reported as hydrogen.

(*d*) Nonliquefaction of gelatin.

(*e*) Fermentation of lactose with gas production.

(*f*) Indol production.

(*g*) Reduction of nitrates to nitrites.

To these may be added the acidifying and coagulation of litmus milk without subsequent digestion of the casein. The production of gas and fluorescence in glucose neutral red bouillon is also a very constant function of the colon bacillus. *B. lactis aerogenes* is similar to *B. coli*, with the exception of nonmotility and production of gas in saccharose media. *B. lactis anærogenes* is also similar to *B. coli*, but does not produce gas in glucose and lactose.

The reduction of neutral red with a greenish-yellow fluorescence is very striking and has been suggested as a test for the colon bacillus. Many other organisms, especially those of the hog cholera group, have this power. It is convenient, however, to color glucose bouillon with about 1 per cent. of a ½ per cent. solution of neutral red.

On the plates made for the detection of colon bacillus may be found certain organisms which have origin in fecal contamination. The more important of these are those of the paratyphoid, cloaca, and proteus groups. In addition, the *B. fecalis alkaligines* has not rarely been isolated. Among natural water bacteria there may be present either the liquefying or the nonliquefying *B. fluorescens*. These colonies have a yellowish-green fluorescence.

Certain chromogenic cocci and bacilli are found in uncontaminated waters as *B. indicus* or *B. violaceus*. From surface washings we obtain certain soil bacteria, as *B. mycoides*, *B. subtilis*, *B. megatherium*. One of the higher bacteria which shows long threads, *Cladothrix dichotoma*, is common, and is characterized by a brown halo around its gelatin plate colony.

Isolation of the Typhoid Bacillus from Water.—This is probably the most discouraging procedure which can be taken up in a laboratory. Only the most recent

reports of such isolation from water supplies, which have been verified by immunity reactions, can be accepted, and of these the number of instances is exceedingly small. Owing to the long period of incubation, the typhoid organisms may have died out before the outbreak of an epidemic suggests the examination of the water supply.

There have been various methods proposed for the detection of the *B. typhosus* in water. A method which would offer about as reasonable a chance of success as any other would be to pass 2 or 3 liters of the water through a Berkefeld filter; then to take up in a small quantity of water all the bacteria held back by the filter. Then plate out on lactose litmus agar and examine colonies which do not show any pink coloration. The dysentery bacillus has about the same cultural characteristics as the typhoid one, so that it is important to note motility. If from such a colony you obtain an organism giving the cultural characteristics of *B. typhosus*, carry out agglutination and preferably bacteriolytic tests as well. Some strains of typhoid, especially when recently isolated from the body, do not show agglutination.

The Conradi-Drigalski, the malachite-green, and various caffeine containing plating media have been highly recommended.

Isolation of the Cholera Spirillum from Water.—The method proposed by Koch in 1893 does not seem to have been improved upon by later investigators. To 100 c.c. of the suspected water add 1 per cent. of peptone and 1 per cent. of salt. Incubate at 38°C., and at intervals of eight, twelve, and eighteen hours examine microscopically loopfuls taken from the surface of the liquid in the flask. So soon as comma-shape organisms are observed, plate out on agar. The colonies showing morphologically characteristic organisms should be tested as to agglutination and bacteriolysis. Inasmuch as the true cholera spirillum shows a marked cholera-red reaction it is well to inoculate a tube of peptone solution from such a colony and add a drop of concentrated sulphuric acid after incubating for eighteen hours. The rose-pink coloration is given by the cholera spirillum with the acid alone—the nitroso factor in the reaction being produced by the organism.

Chemical Examination of Water

The examination of water to determine the probability of pollution and fitness for domestic purposes includes the estimation of total solids, free and albuminoid ammonia, nitrogen as nitrite and nitrate, chlorine, oxygen-consuming power, and hardness. While the foregoing are the necessary factors for the object in view, the following physical characteristics are also usually noted: Color, odor, turbidity, and comparative quantity of sediment. In addition to these the degree of alkalinity, although having no bearing on purity, is often of service, and a method for its determination will be included.

The quantities of the various ingredients present are now very generally expressed in parts per million or the number of grams of the ingredients contained in 1,000,000 grams of the water. Unless the water is highly mineralized results of sufficient accuracy are obtained if 1000 c.c. of the water are considered as 1000 grams. Parts per million can be converted into grains per United States gallon by multiplying by 0.0584.

Color.—Color is determined by filling with the sample a tube 2 feet long and capable of being closed at both ends by a glass plate and then looking through the long axis at a white surface. Although attempts to fix standards have been made it is sufficient to note, in general terms, the color observed. Color has no bearing whatever on purity.

Odor.—Odor is determined by half filling a flask with the sample and bringing it to boiling, the odor being noted.

Turbidity.—Turbidity is determined by comparing a column of sample with equal column of distilled water containing known quantities of finely divided silica. The results can be expressed in parts per 1,000,000. This characteristic has to do almost entirely with efficiency of clarification processes.

Sediment.—Sediment can originally be present or can form during storage. It can be either organic or inorganic. Its character rather than its quantity and whether originally present or developed during storage should be determined. When collected and dried and placed upon a piece of platinum foil or in a porcelain capsule it will burn freely and leave but little residue if organic; if inorganic it will change color and volume, but its weight will not be affected to so great an extent. Ferric hydrate separates from many waters. It can be identified by collecting on a filter, dissolving in dilute HCl and then adding a little of a solution of potassium ferrocyanide, which will produce a deep blue color if iron is present. To identify the nature of sediments generally requires application of principles of qualitative analysis.

For the following processes the sample must not be filtered unless so directed, and must be well mixed before withdrawing a portion for a determination.

Total Solids.—Total solids consist of all solids dissolved and suspended in the water. To determine the quantity place 200 c.c. of the sample in a porcelain or platinum dish of known weight, evaporate to dryness, best on a water bath, dry the residue at 120°C., cool, weigh. The increase in weight of dish represents the total solids in 200 c.c. of sample. The results should be expressed in parts per 1,000,000. The dish used should be small and the water added to it in successive small portions as the evaporation proceeds until all of the 200 c.c. have been added.

Free Ammonia.—Free ammonia consists of the NH_3 existing as such together with that which is present in the ammonium salts. It results from natural oxidation of organic nitrogenous matter, but can be derived by reduction of nitrates and nitrites, or it can be an accidental addition.

The solutions necessary for the estimation of the ammonias are:

Ammonia-free Water.—Add sodium carbonate to water to the extent of 1 gram to the liter, place in a still and boil, and when distillate ceases to give reaction with Nessler's reagent collect remainder of it in a clean glass-stoppered bottle. Several liters of this will be required.

Sodium Carbonate.—Dissolve about 40 grams of dry sodium carbonate in 250 c.c. of distilled water.

Alkaline Potassium Permanganate.—Dissolve 200 grams of solid potassium hydrate and 8 grams of potassium permanganate in about 1400 c.c. of water. When solution is complete evaporate until volume measures about 1000 c.c. Keep in glass-stoppered bottle.

Nessler's Reagent.—Take two portions of distilled water of about 400 c.c. each. In one dissolve 13 grams of mercuric chloride and in the other 35 grams of potassium

iodide; when solution is complete add with constant stirring the mercuric chloride to the potassium iodide until a small quantity of the red precipitate which forms remains undissolved. Heat this mixture nearly to the boiling point and allow to stand from twelve to twenty-four hours. Then add 160 grams of solid potassium hydrate (or 120 grams solid sodium hydrate) and stir until dissolved. Now add enough mercuric chloride solution to produce again a fairly abundant permanent precipitate and enough water to make approximately 1000 c.c. of solution. Allow to settle and then use only the clear, slightly yellowish supernatant fluid.

This reagent is an alkaline solution of potassium mercuric iodide, $HgI_2.2KI$. With very small quantities of ammonium it produces a yellowish brown color, and with larger quantities precipitates are formed. It improves with age.

Standard Ammonia.—Dissolve 0.315 gram of pure ammonium chloride in 100 c.c. ammonia free distilled water, then dilute 1 c.c. of this solution to 100 c.c. with the ammonia free water. Then each cubic centimeter of the latter solution, which is the standard, will contain 0.00001 gram NH_3.

In a retort of about 1200 c.c. capacity place about 300 c.c. of ammonia free water and 10 c.c. of the sodium carbonate solution; heat a small piece of pumice and while still red hot drop into the solution in the retort. The retort is then connected with a condenser and heat applied and distillate is collected in 50 c.c. Nessler jars until a portion is obtained which does not give a reaction when 2 c.c. of Nessler's solution is added to it. What has been done so far is merely to free the distilling apparatus of all ammonia. The distillates so far collected are now thrown away. Now, without disturbing its contents, add to the retort 500 c.c. of the sample under examination. Make connections tight and carry on distillation, catching distillate in 50 c.c. Nessler jars which have previously been thoroughly washed and then finally rinsed with a little ammonia free water. As each 50 c.c. portion is collected 2 c.c. of the Nessler reagent are added to it, the tip of the pipette containing the reagent being held some distance above the surface of the distillate to insure complete diffusion and mixing, which would not occur if the reagent, because of its density, were gently added.

A set of standards is now prepared by adding to a series of 50 c.c. Nessler jars, cleaned as directed above, 0.5, 1.0, 1.5, 2.0, etc., c.c. of the standard ammonia solution, adding to each jar sufficient ammonia free water to make 50 c.c. and then to each jar add 2 c.c. of Nessler's reagent as directed. Allow to stand about ten minutes. This gives a set of standards that contain, respectively, 0.000005, 0.00001, 0.000015, 0.00002, etc., gram of ammonia. Now compare the color of each portion of distillate with the standards, the observation being made through the long axis of the tube, and note the quantity of ammonia in the standards that match the distillates in color. It is obvious that the portions of distillate contain the same quantity of ammonia as the standards of same color. Then the sum of these quantities will be the weight of ammonia in 500 c.c. of sample. From this the calculation of parts per 1,000,000 is made.

Example.—The fourth 50 c.c. of distillate showed only a very slight reaction with the Nessler reagent. The first 50 c.c. portion when compared with the standards was found to have the same color as the standard containing 0.00002 grams NH_3, the second portion of distillate the same color as the standard containing 0.00001, and the third portion matching that containing 0.000005, then:

0.00002
0.00001
0.000005
trace

0.000035 equals quantity, in grams, free NH_3 in 500 c.c. of sample.
2

0.000070 equals quantity, in grams, free NH_3 in 1000 c.c. of sample.

then 0.00007 × 1000 equals 0.07 free ammonia expressed in parts per 1,000,000.

The sodium carbonate solution is placed in the retort to liberate NH_3 from ammonia salts. The reaction occurring between the Nessler reagent and ammonia is:

$$2(HgI_2.2KI) + NH_3 + 3KOH = NHg_2IH_2O + 7KI + 2H_2O,$$

the body giving rise to the color being hydrated dimercuriammonium iodide.

It frequently happens that upon the addition of the Nessler solution a greenish color instead of a yellowish brown develops, thus rendering it impossible to compare the distillates with the standards. In such a case continue the distillation until a reaction with Nessler ceases to be given, then determine the albuminoid ammonia as directed below. After that determine the total ammonia by taking a fresh 500 c.c. of sample, immediately adding 50 c.c. of alkaline permanganate and distilling and estimating the ammonia in the usual way. The difference between total and albuminoid will be the free ammonia.

It is important to note that the Nessler reagent must under no circumstances be placed in the jar before distillate or standard; it must always be the last added.

The heat under the retort should be so adjusted that fifteen minutes will be required to collect 50 c.c. of distillate. If a more rapid rate of distillation than this is carried on, very low results are likely to follow.

Albuminoid Ammonia.—This ammonia is derived through the oxidation of the contained nitrogenous organic matter by the permanganate and is in a comparative way the measure of such organic matter.

Without disturbing the contents left in the retort from the estimation of free ammonia, add 50 c.c. of the alkaline permanganate solution and continue the distillation, collecting and Nesslerizing the distillate as in the determination of free ammonia, the calculation of quantity being made in the same way.

Nitrogen as Nitrite.—Of the several methods for detecting and estimating the nitrite nitrogen that of Greiss seems the best.

The following solutions will be required. It is essential that all water used in their preparation should be free from nitrite. The use of distilled water is not essential.

Sulphanilic Acid.—Dissolve 0.350 gram of sulphanilic acid ($C_6H_4(NH_2)HSO_3$) in 100 c.c. of 3 per cent. acetic acid.

Naphthylamine Hydrochloride Solution.—Boil 0.05 gram of naphthylamine hydrochloride ($C_{10}H_7NH_2$) in 10 c.c. of water, quickly strain through a small plug of cotton, and mix the filtrate with 90 c.c. of 3 per cent. acetic acid.

Standard Sodium Nitrite.—Since sodium nitrite is rarely pure this solution is best indirectly prepared. To a strong solution of silver nitrite add a strong solution of sodium nitrite, heat until precipitate formed is redissolved, quickly filter and allow filtrate to cool; the crystals which separate are filtered off and dissolved in a small quantity of hot water. The solution is allowed to cool and filtered and the crystals of silver nitrite now on the filter are dried. Weigh out 0.275 gram of the silver nitrite, dissolve in a little hot water and add to it about 0.2 gram of sodium chloride and then water enough to make 250 c.c.; mix and allow to stand in the dark until clear. Dilute 10 c.c. of clear solution to 100 c.c. with water; each cubic centimeter of the latter solution of sodium nitrite will contain 0.00001 gram nitrogen as nitrite. To 50 c.c. of the water under examination, contained in a Nessler jar add 2 c.c. each of sulphanilic acid and naphthylamine solutions, using separate pipettes for measuring, and mix by means of a glass rod. At the same time dilute 1 c.c. of the standard sodium nitrite solution with 45 c.c. of water and then add 2 c.c. each of the reagents as before. After a lapse of half an hour these solutions are examined, observations being made through the long axis of the tube. If the water has remained colorless, nitrites are absent. If it has become pink or red, nitrites are present. To determine the quantity, compare the color with that produced in the tube containing the 1 c.c. of standard nitrite. If the color is darker than the standard, which will not often be the case, repeat the whole experiment—that is, with both standard and water—but instead of 50 c.c. use a smaller but known quantity of water diluted to 50 c.c. Then into a third Nessler jar pour from the tube containing the 1 c.c. of standard just sufficient of the mixture to match the color produced in the sample and note the volume required; this volume when multiplied by 0.0000002 (for each cubic centimeter of solution in the tube containing the 1 c.c. of standard contains this quantity of N as nitrite) will give the quantity of N as nitrite in the quantity of water tested. The parts per 1,000,000 can be readily calculated from this.

Example.—The color produced in 50 c.c. of water was exactly matched by 15 c.c. of the solution from the tube containing the standard. Then 15×0.0000002 equals 0.000003, which is the quantity of nitrite in 50 c.c. of water. In 1000 c.c. of water there would be 0.000003×20 equals 0.00006 and this multiplied by 1000 gives 0.06. The nitrogen as nitrite is therefore 0.06 parts per 1,000,000.

The red color formed in the test is naphthylamineazobenzenesulphonic acid ($C_6H_4(HSO_3)N_2C_{10}H_6NH_2$).

The complete reaction is:

$$C_6H_4(NH_2)HSO_3 + HNO_2 + C_{10}H_7NH_2 = C_6H_4(HSO_3)N_2C_{10}H_6NH_2 + 2H_2O.$$

The source of nitrites in water is primarily the nitrogenous organic matter originally present and they result from the action of certain kinds of bacteria. They can be formed by the reduction of nitrates through purely chemical action.

Nitrogen as Nitrate.—The picric-acid method is the most satisfactory for the detection and estimation of the nitrates. For this the following solutions will be necessary.

Phenolsulphonic Acid.—Mix 3 grams of concentrated sulphuric acid with 9 grams of pure phenol and heat the mixture in a steam oven at 100°C. for six hours. This

substance frequently solidifies on cooling. It can easily be rendered fluid by the application of a little heat. The formula for this acid is $C_6H_4(OH)HSO_3$.

Standard Potassium Nitrate.—Dissolve 0.722 gram of potassium nitrate in 1000 c.c. of distilled water. Each cubic centimeter of this solution contains 0.0001 gram of nitrogen as nitrite.

To 50 c.c. of the sample add a drop or two of sodium carbonate solution and then evaporate to dryness in a small porcelain dish, using a water bath for the purpose. Mix the dry residue so obtained with 1 or 2 c.c. of phenolsulphonic acid. Now add about 25 c.c. of water and transfer to Nessler jar, then add ammonium hydroxide until, after thoroughly mixing, the liquid smells strongly of ammonia. If a yellow color develops nitrates are present. Make the volume up to 50 c.c with water. In a small porcelain dish evaporate 5 c.c. of the standard potassium nitrate solution, treat this residue with phenolsulphonic acid, water, and ammonia, and make up to 50 c.c. Each cubic centimeter of this solution will contain 0.00001 gram nitrogen as nitrate. Match the yellow shade produced by the water with that produced by the standard nitrate solution in precisely the same manner as the pink shades due to nitrites were matched and make calculation in the same way. Just as in the nitrites, use a smaller quantity of the water if the shade produced by 50 c.c. of it is darker than the standard, although in this case a new standard need not be prepared.

Example.—The color produced by 50 c.c. of water was equaled by 40 c.c. from jar containing the 5 c.c. of standard. Then 40 by 0.00001 equals 0.0004 gram N as nitrate in 50 c.c. of sample. In 1000 c.c. there would be 0.0004 by 20 equals 0.008 gram, and this multiplied by 1000 gives 8. The nitrogen as nitrate, therefore, amounts to 8 parts per 1,000,000.

Chlorides when present in a quantity larger than 20 parts per 1,000,000 seriously interfere with this estimation and should be removed. This can be done by adding to 100 c.c. of the sample a number of cubic centimeters of a solution of silver sulphate corresponding to one-tenth the number of parts of chlorine per 1,000,000, the strength of the silver sulphate to be 2.87 grams per liter, then making the volume up to 200 c.c. with distilled water, filtering and evaporating 100 c.c. of this filtrate to dryness. This 100 c.c. of filtrate represents but 50 c.c. of sample. Silver sulphate can be prepared by adding solution of sodium sulphate to a solution of silver nitrate and washing the precipitate with repeated portions of very cold water until every trace of nitrate is removed.

The nitric acid liberated by the phenolsulphonic acid converts an equivalent quantity of phenol into trinitrophenol according to the equation:

$$C_6H_4(OH)HSO_3 + 3HNO_3 = C_6H_2(OH)(NO_2)_3 + H_2SO_4 + 2H_2O.$$

Picric acid is not nearly so intense a yellow coloring matter as ammonium picrate and for this reason the ammonia is added, the following equation resulting:

$$C_6H_2(OH)(NO_2)_3 + NH_4OH = C_6H_2ONH_4(NO_2)_3 + H_2O.$$

The principal source of nitrates is through the oxidation of nitrogenous organic matter that has entered water. In many localities rain washes rather a notable quantity of nitrate from the atmosphere. Another source is from soil in which at-

mospheric nitrogen has been converted into nitrate through the action of certain varieties of bacteria during the growth of certain kinds of plants.

Chlorine.—In the estimation of the quantity of chlorine present the following solutions will be required.

Standard Silver Nitrate.—Dissolve 4.795 grams of pure crystallized silver nitrate in sufficient distilled water to make 1000 c.c. of solution. Each cubic centimeter of this solution will precipitate 0.001 gram of chlorine.

Potassium Chromate.—Dissolve 2 grams of yellow potassium chromate in 100 c.c. of distilled water. To insure freedom from chlorine add a few drops of the silver nitrate solution and filter.

Owing to the widely varying quantities in which chlorine occurs, it is essential that a qualitative test be first made to determine whether it is present in very small, moderate, or large quantity, for the mode of procedure in the estimation will depend upon this. To make the qualitative test place about 10 c.c. of sample in a test tube, add 2 or 3 drops of nitric acid, and then about 1 c.c. of a strong (5 per cent.) solution of silver nitrate. Note whether merely a slight opalescence, a decided milkiness, or a heavy precipitate is produced.

If only an opalescence is produced in the above test evaporate a large but known volume until its bulk is from 50 to 75 c.c., add 8 to 10 drops of the potassium chromate, and then from burette add the standard silver solution until a permanent but very faint pink tinge is obtained. (It is a mistake to add the silver until a red color is produced; indeed the addition of the silver should cease when the appearance of the solution changes from a brilliant to a dull yellow.) Note the number of cubic centimeters of silver solution required. This multiplied by 0.001 will give the quantity of Cl in the volume of water evaporated; determine the quantity in 1000 c.c. and from this calculate the parts per 1,000,000.

When the qualitative test produces a reaction ranging from milkiness to a small quantity of curdy precipitate in intensity, concentration of the water by evaporation is not necessary. Measure out 100 c.c. of the sample, add 10 to 15 drops of the potassium chromate, and titrate with the standard silver solution as before. The calculation of results is made as before.

When the reaction obtained in the qualitative test is productive of a copious curdy precipitate, small quantities, such as 10, 20, or 50 c.c. of the sample, are diluted with distilled water and titrated as in the preceding paragraph. In waters of this class, weights rather than volumes should be used for the various estimations.

Examples.—Qualitative test showed only a slight opalescence. Evaporated 200 c.c. of sample to about 60 c.c., added the potassium chromate and then the standard silver solution, 5 c.c. of which were required to produce the faint pink color. Then five times 0.001 equals 0.005 gram chlorine in 200 c.c. of sample or 0.025 in 1000 c.c. Then 0.025×1000 equals 25 parts Cl per 1,000,000.

In another sample the qualitative test gave a decided milkiness. Measured 100 c.c. of sample, added potassium chromate, and then the standard silver solution, 3 c.c. of which were required. Then 3×0.001 equals 0.003 gram Cl in 100 c.c. of sample and 0.003×10 equals 0.03 gram in 1000 c.c., and finally 0.03×1000 equals 30 parts of Cl per 1,000,000.

Chlorine exists in water principally in the form of sodium chloride and is derived normally either through the disintegration of rocks and soil or from the air especially

near the sea coast and in close proximity to the sea coast from infiltration of sea water. The quantity will normally vary then with the nature of the strata through which the water passes and inversely with the distance from the ocean. Abnormally it is derived from animal excreta.

Oxygen-consuming Power.—The solution required in this process are:

Standard Potassium Permanganate.—Dissolve 0.3925 gram potassium permanganate in 1000 c.c. of distilled water. Each cubic centimeter of this solution will contain 0.0001 available oxygen.

Standard Oxalic Acid.—Dissolve 0.7875 gram of pure crystallized oxalic acid in 1000 c.c. of distilled water. Each cubic centimeter of this solution should decolorize exactly 1 c.c. of the permanganate.

Dilute Sulphuric Acid.—Pour 75 c.c. of pure concentrated sulphuric acid into 350 c.c. of distilled water. Heat to boiling and add the permanganate solution little by little until the acid attains a permanent faint pink color. This treatment with permanganate is necessary because sulphuric acid frequently contains comparatively large quantities of oxidizable substances.

Although the permanganate and oxalic acid solutions were prepared so as to be exactly equivalent, it is essential that their actual relation be determined experimentally. To do so measure into a beaker exactly 10 c.c. of the oxalic acid, add approximately 150 c.c. of distilled water and 25 c.c. of the dilute sulphuric acid. Heat nearly to the boiling point and from a burette add permanganate solution until a permanent faint pink color is produced. Note the quantity of permanganate used as it will be necessary to use the figure in the estimation.

The oxygen-consuming power of the water is now carried out as follows: Into a beaker of sufficient size measure 200 c.c. of the water, add 25 c.c. of the dilute sulphuric acid and from a burette 15 c.c. of permanganate and then boil this mixture for ten minutes, during which time more permanganate is added if the red color present tends to fade. Remove lamp and add oxalic acid in exact 10 c.c. portions until the solution in beaker becomes absolutely colorless and contains no brown or black floccules. Now from the burette continue to add the permanganate solution until a permanent faint pink color is produced. From the permanganate added to the beaker subtract a quantity equivalent to the total quantity of oxalic acid added. This difference multiplied by 0.0001 will give the quantity of oxygen consumed by 200 c.c. of the water. Obtain the result in parts per 1,000,000 in the usual way.

Example.—Found experimentally that it required 10.1 c.c. of the permanganate to produce faint pink color with 10 c.c. of the oxalic acid. Placed 200 c.c. of sample in beaker, added 25 c.c. of dilute sulphuric acid and then from a burette (in which the solution stood at zero) added 15 c.c. of permanganate. Brought mixture to boiling and after five minutes, because of fading of red color, added 5 c.c. more of the permanganate and continued the boiling. Removed lamp and added, by means of pipette, exactly 10 c.c. of the oxalic acid. The solution now had a slightly brownish color, so added exactly 10 c.c. more of the oxalic acid. The solution now became colorless. Then continued to add from burette the permanganate solution until faint pink color was obtained. On reading burette found that the total quantity of permanganate added was 26 c.c. Since 20 c.c. of oxalic had been added and each 10 c.c. of it was equivalent to 10.1 c.c. of permanganate then 10.1×2 equals 20.2 c.c., which must be subtracted from 26 to find the quantity of permanganate con-

sumed by the 200 c.c. of water. This difference is 5.8 c.c. Then, 0.0001 × 5.8 equals 0.00058 gram oxygen consumed by 200 c.c. of water and 0.00058 × 5 equals 0.0029 gram consumed by 1000 c.c. Then, 0.0029 × 1000 equals 2.90, is the oxygen consumed expressed in parts per 1,000,000.

Nitrites, hydrogen sulphide, and ferrous salts consume permanganate and if present, which is occasionally the case, must be rendered inert by boiling the water for fifteen minutes after the addition of the dilute sulphuric but before the addition of any permanganate.

The oxygen consumed or required is an index of the total quantity of organic matter present and therefore supposedly an index of purity. When it is considered that a water may contain organic matter of either animal or vegetable origin and either nitrogenous or non-nitrogenous in nature and that all these decompose permanganate with equal facility, it can readily be understood that a high oxygen consuming power does not necessarily indicate pollution, but merely that a large quantity of organic matter is present. It does not, like the albuminoid ammonia, indicate any particular kind of organic matter.

Hardness.—The Clark soap method, while not giving absolutely accurate results, is sufficient for all practical purposes, although some little experience is necessary if good results are to be expected. The following solutions are required:

Standard Calcium Carbonate.—Dissolve 1 gram of pure calcium carbonate in a little hydrochloric acid, evaporate to dryness on a water bath, then dissolve the residue in a liter of distilled water. Each cubic centimeter of this solution contains the equivalent of 0.001 gram of calcium carbonate.

Standard Soap Solution.—Dissolve 10 grams of pure castile soap in a liter of 70 per cent. alcohol and filter. This solution must be standardized by titrating it against a known volume of the calcium carbonate solution. This is done as follows: In a flask of about 200 c.c. capacity place 100 c.c. of distilled water. Then from a burette add soap solution, 0.1 c.c. at a time, shaking vigorously after each addition until a permanent lather forms. The lather should persist for five minutes. Note the quantity of the soap required. Repeat the experiment and take the average quantity of soap used. This will be the quantity of soap required to produce a lather in 100 c.c. of distilled water, a figure that is important and to be used later. Now clean out the flask and place in it 10 c.c. of the standard calcium carbonate solution and 90 c.c. of distilled water. Then from a burette add the soap solution, 0.25 c.c. at a time, shaking vigorously between each addition until a permanent lather is produced. Note the quantity of soap required. Repeat the experiment and find the average quantity of soap used.

From the quantity of soap required for 10 c.c. of calcium carbonate plus the 90 c.c. of distilled water subtract the quantity required for 100 c.c. of distilled water. This will be the number of cubic centimeters of soap solution used by 0.01 gram of calcium carbonate.

Two important points are that the soap solution must not under any circumstances be added in greater quantity than 0.25 c.c. at a time and that rather vigorous shaking after each addition is necessary. In a duplicate determination these precautions must be observed just as faithfully as in the original.

Example.—One hundred cubic centimeters of distilled water required 0.6 c.c. of the soap solution to produce a lather; 10 c.c. of the calcium carbonate plus 90 c.c. of

distilled water required 11.7 c.c. of the soap. Then 11.7 minus 0.6 equals 11.1 c.c. of the soap required for 0.01 gram of calcium carbonate. Hence 0.0100 divided by 11.1 equals 0.0009; that is, each cubic centimeter of the soap solution will present 0.0009 gram of calcium carbonate. The soap solution is not stable, so it should be frequently standardized.

To estimate the hardness of water place 100 c.c. of the water in the flask and add soap solution from a burette, 0.25 c.c. at a time, shaking vigorously between each addition, until a permanent lather forms. Note the number of cubic centimeters of the soap solution required; repeat the experiment and take the average quantity of soap used. From this quantity deduct the quantity of soap required to produce a lather with 100 c.c. of distilled water. This difference multiplied by the value of the soap solution will give the quantity of calcium carbonate represented in 100 c.c. of the water. The quantity so found multiplied by 10 will be the quantity in a liter. Express the results in parts per 1,000,000.

Example.—One hundred cubic centimeters of water required 14.6 c.c. of the soap solution to produce a lather; 100 c.c. of distilled water required 0.6 c.c. Each cubic centimeter of the soap equals 0.0009 gram of calcium carbonate. Then 14.6 minus 0.6 equals 14 c.c., the quantity of soap required by the calcium carbonate in 100 c.c. of the water. Fourteen multiplied by 0.0009 equals 0.0126 gram, the quantity of calcium carbonate represented in 100 c.c. of the water and 0.126 gram of calcium carbonate represented in 1 liter of the water; 0.126 multiplied by 1000 equals 126, the hardness in parts per 1,000,000.

Since calcium and magnesium, both of which are generally present in water in varying quantities, form insoluble soaps, then both these must be satisfied before the detergent properties of soap are available. This preliminary consumption of soap without a return in cleansing property is what is commonly known as hardness. Its degree, owing to the varying composition of the article ordinarily known as soap, can be and is better expressed in terms of some substance of invariable composition. Calcium carbonate has been, for obvious reasons, selected for this purpose so that the hardness is said to be equal to so much calcium carbonate. The true meaning of this term is that the calcium and magnesium salts present are equivalent, in precipitating powers, to so much calcium carbonate. The reactions between soap, which for reaction writing purposes may be considered as sodium stearate, $Na\ (C_{18}H_{35}O_2)$, and calcium and magnesium salts are—

$$CaSO_4 + 2(NaC_{18}H_{35}O_2) = Ca(C_{18}H_{35}O_2)_2 + Na_2SO_4.$$
$$MgCO_3 + 2(NaC_{18}H_{35}O_2) = Mg(C_{18}H_{35}O_2)_2 + Na_2CO_3.$$

Hardness is of two varieties, temporary and permanent. The temporary is that due to calcium and magnesium carbonates. It is easily removed by heat and filtration, hence the term temporary. The permanent is due to all other salts of these metals which for removal require the addition of some reagent. Hardness has little if any sanitary significance.

From 0 to 50 parts per 1,000,000 is considered soft.

From 50 to 100 parts per 1,000,000, moderately hard.

From 100 to 300 parts per 1,000,000, hard.

Above 300 parts per 1,000,000, very hard.

Alkalinity.—This is a measure of the carbonates present. The only solution necessary is N/20 sulphuric or hydrochloric acid, for the preparation of which see under "Volumetric Solutions."

Alkalinity is determined by measuring 100 c.c. of water into a beaker, adding 2 drops of methyl orange, and from a burette adding N/20 H_2SO_4 until a distinct pink color is obtained. If desired, the alkalinity can be expressed as being equivalent to a quantity of calcium carbonate. This quantity is obtained by multiplying the number of cubic centimeters of N/20 acid required for 1000 c.c. of the water by 0.0025.

Example.—Added 2 drops of methyl orange to 100 c.c. of sample and from burette added N/20 H_2SO_4. It required 1.5 c.c. of this; hence 1000 c.c. would require 15 c.c. Then fifteen times 0.0025 equals 0.0375 gram $CaCO_3$; and 0.0375 times 1000 equals 37.5 $CaCO_3$; that is, the alkalinity is equivalent to 37.5 parts calcium carbonate per 1,000,000.

Incrustants.—Occasionally it is desirable to determine the approximate quantity of scale that would be formed by water when used in boilers. This can be found by evaporating 200 c.c. of sample to dryness in a weighed dish, in exactly the same manner as for total solids. Then cover the residue with 60 per cent. alcohol and allow to stand, with occasional rotation, for twenty minutes; then, without making any effort whatever to dislodge any of the residue from the dish, filter through ashless paper; treat the residue twice more with 60 per cent. alcohol. Dry filter, burn, and add ash to dish. Dry and weigh dish and contents. Increase in weight will be scale forming material in 200 c.c. of sample. Express the result in parts per 1,000,000.

At times it is necessary to clarify and decolorize a water before an estimation of the nitrates, nitrites, or chlorine can be made. This can be accomplished by adding 1 gram of alum to 500 c.c. of the water, stirring until dissolved, and then adding a few drops of strong sodium carbonate solution, mix and allow to stand a short time, during which a copious precipitate of aluminum hydrate will form. Filter. The alum and sodium carbonate must not contain any of the substances mentioned.

It is not possible to state definitely the quantity of any particular ingredient that should be present in potable water, but in order that a fair idea may be had of what one might reasonably expect to find, the following table, compiled from various sources, is given, the quantities being expressed in parts per million.

Source	Free ammonia	Albuminoid ammonia	Chlorine	Nitrite	Nitrate	Required oxygen
Rain water	Usually high	Trace to 0.10	Trace to 8	.....	Trace to 0.5	
Spring water	0 to 0.10	Trace to 0.10	Trace to 10	Slight trace	Trace to 2	1 to 2.
Deep-well water	Usually high	Trace to 0.10	Usually high, from 15 up.	Trace	5 to 7	
River water	0 to 0.06	Trace to 0.10	3 to 10	Slight trace	1 to 4	5 to 7.
Distilled water	.....	.....	0 to 50			

In the above table traces of nitrites are stated to be a normal ingredient of spring water, river water, and deep-well water. This is true only in limited sense; therefore it would be better to consider the presence of nitrites, even in traces, as a suspicious sign.

Poisonous Metals.—The question of poisonous metals, especially lead and zinc, is of such importance that the plan of applying the so-called quick and simple tests should be condemned, for like many tests of the kind experience has proven that they are of little value except in the hands of an expert.

Still, keeping in view the necessity for methods which are not too involved, the following tests are given for the detection of these metals when occurring alone. Should the presence of two or more be suspected in the same sample then recourse must be had to those methods which are found in complete works on qualitative analysis.

Lead.—To ½ liter or more of the water add 4 to 5 drops of sulphuric acid and then evaporate until the volume has been reduced to about 10 c.c. Now add a little tartaric acid and then enough ammonium hydrate to make alkaline; boil for a few moments and filter. Cool the filtrate and add sufficient acetic acid to make acid. Add now a few drops of potassium chromate and allow to stand for some time. A yellow precipitate proves the presence of lead.

As lead occurs only in small quantities it is important to remember that the larger the volume of the water concentrated the more positive and reliable will be the test. Three or 4 liters would give better results than half a liter. It is equally important to keep the volume of solution as small as possible after concentration has been completed.

Copper.—Concentrate as under lead and filter. To the filtrate, which should not be too strongly acid, add a few drops of a freshly prepared solution of potassium ferrocyanide. If a chocolate red or brown precipitate is obtained, copper is present. The precipitate disappears on the addition of an excess of ammonia, and a blue solution will result. Should the precipitate produced be white, lead or zinc and not copper is present.

Zinc.—Concentrate as under lead, and filter. To the filtrate, which should not be strongly acid, add a few drops of a freshly prepared solution of potassium ferrocyanide. A white precipitate proves the presence of zinc. The precipitate disappears on addition of an excess of ammonium hydrate.

Lead and zinc give exactly the same reaction with this test—that is, a white precipitate. It is necessary to prove the absence of lead before the test can be applied to zinc.

No examination of a specimen of water can be **complete without** a careful **examination of** its **sediment**—after **centrifuging if necessary**—to determine the presence of amœbæ and of the several water-borne animal parasites, which infect man.

Permissible Limits of Pollution of Water.—The following standards are given as maximum permissible limits of pollution:

Chlorine, no limit. Must be considered in relation to the chlorine content of unpolluted water in surrounding country.

Bacteria, not over 100 per cubic centimeter.

Bacillus Coli should not be present in more than one of five 10 c.c. samples of surface water, and absent from ground water.

	Parts per million
Free ammonia	0.03
Albuminoid ammonia	0.35
Nitrites	None or at most a trace (0.0004)
Nitrates	1.6

The following is an analysis of an excellent water taken from a bored well which now supplies water to one of our large camps (Quantico):

Bacteriological.—No gas formers (*B. coli*) in 56.5 c.c.

Chemical.

	Parts per million
Total solids	12.0
Chlorine	2.0
Free ammonia	0.14
Albuminoid ammonia	0.26
Nitrites	None
Nitrates	None

Purification

The purification of polluted water is secured through:

1. Sterilization with heat:
   - (*a*) Distillation;
   - (*b*) Boiling;
   - (*c*) Heat exchange:
     The Forbes-Waterhouse apparatus.
2. Filtration:
   - (*a*) Domestic:
     1. Pasteur-Chamberland;
     2. Berkefeld, etc.;
   - (*b*) Municipal:
     1. Slow sand;
     2. Mechanical.
3. Chemical purification:
   - (*a*) Alum;
   - (*b*) Halogen group, except fluorine:
     1. Bromine;
     2. Iodine;
     3. Chlorine;
   - (*c*) Calcium hypochlorite;

(*d*) Sodium bisulphate;
(*e*) Potassium permanganate;
(*f*) Hydrate of iron;
(*g*) Ozone;
(*h*) Chloramine-T.

4. Ultra-violet rays.

1. Sterilization with Heat

(*a*) **Distillation.**—This method is best of all methods of water purification. Proper distillation gives a pure water, free of bacteria and suspended matter, as well as dissolved salts. Gases may go over with the distillate and in foul harbors may be sufficiently concentrated to produce gastro-intestinal symptoms in those drinking the distillate. All distilled water requires aeration to be palatable.

(*b*) **Boiling.**—Boiling is the next safest method. It kills micro-örganisms and precipitates the carbonates, thus removing temporary hardness. The content of organic matter in the water is not reduced. The water is flat and needs aeration. In camp a perforated tin cup, stirring the water, or allowing it to flow through the perforated bottom of an elevated metal receptacle into a bucket below will render boiled water palatable. Boiling is available when the elaborate apparatus for distillation cannot be had. It is usually practicable for the household while its expense would preclude its use for the purification of water for general distribution in cities. When in doubt boil drinking water. By so doing doubt and infection are both removed.

(*c*) **Heat Exchange Apparatus.**—Various methods of heat exchange apparatus for sterilization of water, especially in the field, have been devised. They all depend upon the principle that a volume of water heated to 180° to 212°F. will give up to a similar volume of cold water an amount of heat within 20°F. of the temperature of the water originally heated. The Forbes-Waterhouse apparatus is used in the field by our Army. Packed it weighs only 90 pounds. This sterilizer supplies 25 gallons per hour of sterile water, at a temperature not over 15° above that of the raw water. This is the best of the small portable heat exchange apparatuses.

Heat exchange apparatus mounted on wheels, capable of supplying 300 gallons of water per hour is in use by certain foreign armies.

While several methods of sterilization of water by heat are most satisfactory from hygienic viewpoint, they are too expensive in their operation to be practicable for use on a large scale, *e.g.*, for city supply.

2. Filtration

Almost complete mechanical removal of pathogenic organisms from a water supply may be accomplished by some kinds of filtration.

Filtration may be:

(*a*) Domestic (for houses):
1. Pasteur-Chamberland;
2. Berkefeld, etc.

(*b*) Municipal:
1. Slow sand;
2. Mechanical.

(*a*) **Domestic.**—Domestic filtration as generally practised in the house is a delusion and a snare. It is worse than useless and causes a false sense of security.

Perhaps the best of home filters is either the Pasteur or Berkefeld. These filters consist of tubes or "bougies" of baked kaolin, the pores of which are very fine. The water to be filtered is supplied around the bougies and the filtrate, after passing through the walls of the tube, is collected in a reservoir for the purpose. The bougies are removable, but they are very frangible. Unless they are actually removed and *boiled* at least twice a week they are apt to become breeders of disease, for the arrested organisms find pabulum in the water and their colonies *actually* grow *through* the bougie in two or three days. The danger of this is easy to see.

Hamilton has devised an ingenious canteen by which polluted water may be filtered through a bougie and drunk. It may be desirable in case troops are operating in small units where pure water cannot be had. But it is believed to be unsafe, for:

1. The bougies must be boiled daily;
2. They are very frangible and apt to break;
3. Their point of union with metal is not necessarily tight against bacteria.

It seems far more desirable to use some chemical method in such circumstances.

Many varieties of domestic filters, some attached to the spigot, are on the market and are a menace rather than a protection, either because of improper handling or because of inherent deficiencies. Most of the domestic filters are useless. The best are a grave menace unless they are sterilized daily.

A Pullman porter once told the writer he did not know the source of the drinking water in his car, but he knew it was pure, because, he said "It is filtheyed every day." No doubt it was!

(*b*) **Municipal Filters.**—The municipal filtration of water is a subject so broad that it is impossible to do more than give it passing notice. Generally speaking municipal water supplies are derived from surface water.

This water, from rivers or lakes, too frequently contains pollution which must be removed by filtration or other means of purification.

1. **Slow Sand Filters.**—For the purification of large water supplies a properly operated slow sand filter process, safeguarded by chemical and bacteriological analysis made daily, is without doubt the best system. It imitates Nature's method of purifying water and has been proved to remove 99½ per cent. of *all bacterial* growth from a polluted water. The objections to the slow sand filter are:

(*a*) The great initial cost;

(*b*) The difficulty of location owing to the large amount of ground required.

Most waters before being permitted to go upon the filter beds should pass through, and remain at least twenty-four hours in a sedimentation basin (simply a small lake) where the matter in suspension is permitted to settle to the bottom. This prevents clogging the filter bed by silt, and renders its necessary cleaning less frequent.

A single filter when empty is a huge vaulted chamber, covering about an acre of ground. The roof is supported by pillars. The floor is of tile with a network of drains let into it, through which the filtered water flows out for use. On this floor is placed first a layer of coarse gravel, then one of finer gravel, next one of sand, and last one of fine sand. This fine sand layer is about 3 to 5 feet in depth, and it constitutes the real filter, the rest of the sand and gravel being used as a bed to keep the fine sand in place, so it will not be washed away through the drains. The gravel also aids in oxidizing substances in the water during filtration.

Above the upper level of the sand there is an air chamber of perhaps 10 feet under the roof. A roof is necessary to prevent freezing and the growth of algæ. This roof is in turn covered by sod and only an occasional man hole showing on a green lawn gives evidence of the subjacent filtration.

Through these man holes there is easy access to the filter beds,

although large doors form the usual entrance. Units of this character may be constructed in number sufficient to supply the needs.

Filter beds, when first laid, are not efficient. It is necessary that a slime layer, or "schmutzdecke" of the Germans, shall first form. This jelly-like deposit consists of minute animal life and bacteria, and extends down into and around the individual sand grains. It does the real work of filtration. It is a biological filter.

The maximum rate of filtration prescribed is not over 4 inches per hour. When the rate of filtration becomes slow the filter must be cleaned. The "schmutzdecke" has become too thick to allow the water to penetrate through it. When this occurs the water is drawn off the filter, and about an inch of the sand is removed by mechanical means. This sand is carefully cleaned, and when, by the process of cleaning, the layer of fine sand on the filter bed has been reduced to a thickness not less than 1 foot, the cleaned sand is brought back and put on the filter bed again.

For convenience of operation filter beds (on a large scale) are laid so as to cover the area of about an acre, and when properly operating will practically remove all bacteria from 2,000,000 gallons of water in twenty-four hours (German maximum is 2,500,000).

Most important is the daily control of the filtrate by chemical and bacteriological analyses, especially the latter.

2. **Mechanical Filtration.**—Mechanical sand filtration is a term applied to the process of forcing water under pressure through a cylindrical filter, generally of wood or iron, containing sand and quartz or gravel, with the use of alum as a coagulant for making a slime layer.

This method is applicable to smaller supplies than the slow sand method, is said to be efficient, and is more easily managed than the "slow sand process."

Harrington states that a method of mechanical filtration combined with treatment of the water with hypochlorites has been found to be "more efficient than either process alone, and has been recommended by competent authorities."

3. Chemical Purification

In time of war coal conservation may necessitate resort to chemical means for purification of water aboard ship. Troops in the field, especially small detachments, often must purify water by chemical means. Some of these are as follows:

(*a*) **Alum.**—The quantity of alum required will vary with the chemical composition of the water to be purified. English authorities arbitrarily place the amount needed as 6 grains per gallon, while Harrington says ¼ grain to the gallon. For the successful action of alum a small amount of calcium carbonate is necessary, and if absent from the water should be supplied in the form of limewater. The reaction between these salts results in the precipitation of alumina hydrate, which is of gelatinous consistence and in settling carries to the bottom suspended microörganisms and other substances.

Care should be exercised that too much alum and lime are not used as excess of either in the water is very undesirable.

(*b*) **The Halogen Group.**—The halogen group are all proposed, with the exception of fluorine, for use in purification of water.

1. Bromine is recommended for use by troops. It is supplied in 2 c.c. capsules containing 0.06 gram of bromine in solution. Each capsule is capable of sterilizing 1 liter of water.

2. Iodine is recommended in similar circumstances. Tablets of iodate of soda are dissolved in the water. Tablets of tartaric acid decompose the salt, and sodium sulphite tablets are added to render the water palatable.

3. Chlorine.—The sterilization of water by chlorine suggested some time ago, after a period of disuse, has been growing in popularity since 1908. It has been used by means of tanks into which the gas has been compressed and is liberated into the water to be purified. A far more satisfactory and practicable method is the application of chlorine in some salt from which it is readily liberated, such as calcium hypochlorite.

(*c*) **Calcium Hypochlorite.**—Perhaps the most conveniently used and available salt for use by the naval medical officer is the calcium hypochlorite issued by the medical department of the Navy.

This salt pulverized, placed in a gauze or cheese-cloth bag, and dragged through the water is very effective in proportion of 1 gram per 100 hundred gallons.

Harrington attributes the following advantages to the hypochlorite process, viz.:

1. Almost complete destruction of pathogenic organisms, especially those of intestinal origin;

2. Reliability and ease of application of the chemical, together with small variation of the required dose;

3. Total absence of poisonous features either in the chemical product as applied to the water, or in any of its resulting decomposition products;

4. Merely nominal cost of chemical and its application;

5. Speed of reaction, making unnecessary any substantial arrangements as to basins other than storage facilities;

6. Substantial saving in the cost of coagulation of waters that are of sufficiently unsatisfactory appearance to require clarification or filtration;

7. Permitting rates of filtration materially in excess of those possible where high bacterial efficiency is required of the filtration process in the absence of sterilization;

8. Reduced clogging of the filter beds, with consequent lengthening of the runs between cleanings due to the destruction of various forms of algæ.

Limitations of the process:

1. Inability to remove or destroy all of the spore-forming bacteria, but which kinds of bacteria are not considered to be pathogenic to man, at least those common to water;

2. Inability to remove bacteria which are imbedded in particles of suspended matter;

3. Inability to remove turbidity;

4. Inability to remove appreciable amounts of color or dissolved vegetable stain;

5. Inability to remove organic matter appreciably;

6. Inability to remove swampy tastes or odors;

7. Inability to remove creosote tastes or odors;

8. Inability to soften water; as a matter of fact the addition of hypochlorite of lime usually results in slight increase in the hardness of water, although this is not ordinarily measurable, notwithstanding the fact that the commercial product usually contains a little free quicklime which reduces slightly the carbonic acid in the water;

9. Difficulties encountered in applying this process, except with greatest care, to waters which contain substantial quantities of reducing agents or compounds capable of oxidation, such as nitrites and unoxidized iron.

It appears to be the consensus of opinion that this process cannot replace filtration.

(*d*) **Sodium Bisulphate.**—Sodium bisulphate, 15 grains to the pint, is said to sterilize water. This is rather strong dosage of the salt for continued administration. It may be used if necessary on the march.

(*e*) **Potassium Permanganate.**—Potassium permanganate may be added until the water to be purified retains a permanent pink color. This has been much used by the British in India and has been found very satisfactory. "Pinking" usually requires 5 centigrams per liter, or 1 grain per quart.

(*f*) **Hydrate of Iron.**—A method of producing hydrate of iron which is flocculent and carries down in its precipitation suspended matter

in water is employed in Europe. Iron scraps are placed in a cylinder containing water, and are agitated in the water. The CO_2 in the water forms a carbonate of iron which is oxidized by the air, and a ferric hydrate is precipitated. This method is too expensive and unsatisfactory to be of general use.

(*g*) **Ozone.**—Recently the German army has been employing an ozonizing process of water purification which appears to be exceedingly satisfactory. The method seems to be applicable to water purification on a small scale.

Air which has been dried by passing over calcium chloride is then ozonized by an electric current, and the water is exposed to the ozone thus formed. The water is said to be sterilized by this apparatus in quantity up to 700 gallons per hour. The apparatus is said to be economical.

(*h*) **Chloramine-T.**—Recently a chloramine from the aromatic toluene has been reported to be the best-known reagent for the chemical sterilization of water.

Water containing 10,000 organisms per cubic centimeter may be sterilized in ten hours when used in proportion of 0.04 gram per liter of water. No unpleasant taste results.

Chloramine-T is stable, non-toxic and non-corrosive.

It is said to be more powerful in its action than sodium hypochlorite, and is easily manufactured.

4. Ultra-violet Rays

The sterilization of water by means of the ultra-violet ray is believed by some to be an excellent and economical method.

Turbidity greatly decreases the sterilizing power of the rays for they cannot pervade the water.

In a competitive test at Marseilles in 1910, such method was found to be quite economical. The rays are produced in a mercury vapor lamp enclosed in quartz which filters the red, green, and yellow rays from the light emitted. The waters are exposed to the rays (*a*) by placing the lamp above the water to be sterilized, and (*b*) by placing the lamp in a chamber through which the water is forced, and falling against baffle plates is directed toward the lamp, *i.e.*, toward the location of maximum intensity of the rays.

This latter method is said to be the more satisfactory. Small

lamps of this type have been proposed for use in domestic purification of water, the lamps being attached to the spigot in a small reservoir.

A water-purifying apparatus has been devised which may be carried in the escort wagon of a regiment and will supply 1 quart per man daily of purified drinking water.

Animal and vegetable microörganisms are killed by this apparatus. Its motive power is gasolene.

On board ship where it is necessary to have electrical power for machinery and for illumination between decks, the principle of sterilization of drinking water by ultra-violet ray may be worthy of consideration when the distillers may not be operated.

The Lyster Bag.—The Lyster bag has proved an exceedingly satisfactory apparatus for use in the chemical purification of water for

FIG. 28.—Lyster bags supported by stacked litters. (*Ford.*)

troops in the field. It consists of a funnel-shaped water-proof bag which resembles a truncated cone in appearance. The mouth of it is kept open by an iron ring hinged at opposite poles of one diameter so that the bag may be folded conveniently for packing. When used the bag is inverted and suspended from a tree limb, tent pole or even from litters which may be stood up as would the poles of a tepee.

Near its apex are several spring faucets from which water may be drawn. These faucets discharge from the bag at a point sufficiently far from the apex to decant the purified water without drawing off any sediment which may have settled to the bottom of the bag.

Chlorinated lime is used for the purification and should be mixed into a paste, then thoroughly stirred up in a small vessel of water, and this strong solution poured into the bag of water to be purified. The contents of the bag should then be stirred thoroughly and the water should not be drunk inside of a half hour. A greater time than this is desirable and water should be prepared at night for use on the following day.

Ampules containing 1 gram each of chlorinated lime guaranteed to yield 30 per cent. of chlorine are supplied for use with this bag, one such ampule being capable of sterilizing a 40-gallon bag of water. Larger bags than the 40-gallon size are made, but this latter size affords a sufficient supply for the daily use of the average company of 100 men.

A sheet of one or more thicknesses of canton flannel should be used as a filter for the removal of twigs, leaves, animals and other gross impurities before application of the chlorinated lime.

The lightness, portability, and convenience of operation are qualities which strongly commend the Lyster bag for use where chemical purification of water is necessary.

Chlorinated water should not be permitted to stand in tin vessels since it acquires a disagreeable taste. When possible it should be stored in earthen ware.

Halozone is said by Dunham and Dakin to be the best agent for chemical purification of water. They claim it will destroy *B. typhosus* in one-half hour when used in proportion of one part to 300,000 of water and that it is cheap, stable, and convenient since it may be supplied in tablets. "Halozone" is p-sulphon dichloramino benzoic acid.

The Darnall Siphon Filter.—The Darnall siphon filter is an ingenious and more complicated apparatus for the purification of water on a small scale and consists of a cylindrical wire cage around which are wrapped several layers of canton flannel sewed together, which form the essential "filter bed" for this filter. The ends of the cylinder are solid metal plates from one of which a siphon tube discharges.

Alum (1 to 5 grains per gallon) may be used as a precipitant in the water to be filtered. Darnall recommends a precipitant composed of aluminum hydroxide and sodium carbonate, in proportions to neutralize each other chemically. This precipitant is applied so as to give 5 grains of the aluminum constituent to each gallon of water to be filtered. The chemicals form a flocculent precipitate which enmeshes the organisms and retains them upon the flannel filter after the water

has passed through it. The flannel-wrapped cylinder is submerged in the water to which the precipitant has been added, and the filtrate going through the flannel enters the cylinder and may be drawn off by siphon action, which is started by a special apparatus for the purpose.

While ingenious and effective, this apparatus, essentially a filter, consists of several parts and is less fool-proof than the simpler Lyster bag by which chemical sterilization of the water is effected. It will be observed that the Darnall apparatus is a bacterial filter (and probably the best of filters for use in the field) while the Lyster bag sterilizes the water by chemical means, is more convenient, and equally, if not more, effective.

CHAPTER X

LIGHT

Light is defined as "the agent which excites in us the sensation of vision."

Several theories have been advanced in explanation of the origin and mode of transmission of light, among which are the

1. Emission or corpuscular theory;
2. The wave or undulatory theory;
3. The electro-magnetic theory.

1. **The emission theory** assumes that luminous bodies emit in all directions extremely small corpuscles or particles of light which proceed in right lines from the source with great velocity. It will be observed that this hypothesis presupposes actual progressive motion on the part of these minute corpuscles.

2. **The undulatory theory** presupposes that all space and all bodies (to a greater or lesser degree) are filled with an all-pervading elastic medium called ether, and that the sensation of vision is due to vibration in spherical waves of this ether, which vibration is due to infinitely rapid vibration of the molecules of the body which is luminous.

In this theory actual movement of translation is not supposed, the vibration affecting various molecules in turn, *e.g.*, wave motion in water.

3. **The electro-magnetic theory,** which has grown more popular since the demonstrations of Maxwell, holds that light and electro-magnetic movement are the same and are but manifestations of the physics of ether.

This theory accounts more satisfactorily for the various phenomena than any theory yet evolved.

Because of its beneficent influences the sun has been worshipped by some, and by others who hold it in less veneration the sun has been held to have great curative powers.

The Indians of Central America frequently are seen lying upon the

ground in the bright sunlight with the sun's rays pouring down at right angle to a diseased part.

This instinctive appeal to the sun's rays while empiric with the Indian is based upon what we regard today as sound therapeusis.

Years ago Arloing and Buchner proved that light rays *alone* are capable of killing broth cultures of pathogenic bacteria; while Ward in 1892–93 showed that spores of *B. anthracis*, which withstand 100°C. and upward, can be killed by rays of reflected light at a temperature far below anything injurious or even favorable to growth of spores. He proved that the bacterial death occurs in the absence of *food*, so it is not merely the effect of altered food. He believed this action due to blue, violet or ultra-violet rays.

The sun is the chief source of light. When one of its rays is passed through a prism this ray will be dissociated or analyzed as it were into seven colors, arranged in order of their refrangibility. They are violet, indigo, blue, green, yellow, orange and red.

These same colors may be reunited into a ray of white light. This white light is necessary to animal and vegetable life, acts beneficially upon health, increases metabolic activity of the body, assists in hæmoglobin formation and oxidizes low forms of animal and vegetable life.

While white light—this end product of the combination of the colors of the visible spectrum—is necessary to the vital processes of animal and vegetable life, certain components, especially if in excess, may prove deleterious to man.

The above-mentioned colors of the visible spectrum, are but the part which is visible to us, of a physical series the higher and lower ranges of which while invisible are physically demonstrable. Analogy indicates that there are rays of greater wave length at one end of the series and of shorter wave length at the other end of this same series than we can actually demonstrate today.

Red rays are produced by much slower vibration than are the violet; in other words the wave length of the red ray is greater than that of the violet; and of the invisible spectrum the rays at the red end, or the invisible infra-red, are longer than red, while those beyond the violet, the ultra-violet, are shorter than the violet.

The **infra-red are heat-producing rays** while the **ultra-violet rays produce chemical change.**

The ultra-violet rays are more highly refrangible, are called actinic or chemical rays and are said to have a wave length of 0.00039 mm.

The sun's ultra-violet rays are largely absorbed by the atmosphere

during the day, but the light reflected from snow, water, sand, etc., contains a greater proportion of these rays than does the atmosphere.

Parsons, Schanz and Stockhausen have shown that the lens of the human eye absorbs the ultra-violet rays, and it seems that these rays are chiefly, if not wholly, responsible for so-called snow-blindness, electric ophthalmia and some of the hyperæsthetic ocular conditions seen in the tropics as result of glare of bright sunlight upon water and white sand. These rays cause fluorescence of the lens in the human eye.

Glassblower's cataract may be caused by the same agent. It has been shown that the proportion of ultra-violet rays emanating from a certain light depends upon the degree of *incandescence* of the carbon in the flame, filament, arc or mantle.

Therefore one must carefully guard against injury to the eyes of those operating or exposed to the intensity of the light of the powerful search lights used aboard ship, electric welding, oxy-hydrogen work, etc.

Sudden overwhelming glare from a very powerful light, or from a short circuit, may cause temporary or even permanent blindness.

But these rays are not an unmitigated curse to man.

The bactericidal power of light has been found to be proportionate to the number of actinic rays which the light contains, therefore we find in sunlight a powerful disinfectant of streams, rivers, the earth's surface, man's excreta, etc.

Other rays, especially the infra-red and red rays (heat rays), have their therapeutic uses also: blue—anæsthesia and sedative; red—in small-pox.

White light, so necessary to man's vital activities and vital processes, must be had either as:

1. Natural illumination; or as
2. Artificial illumination.

Houses should be constructed so that the ratio of window area to floor area will be as 1 to 5, in order to have proper natural illumination.

Aboard ship this is impossible as adherence to this ratio would produce too great structural weakness.

Artificial illumination has not been found which will entirely replace the healthful effects of good daylight upon the human organism.

When daylight cannot be had man utilizes artificial light for his convenience, but not for producing healthful living conditions. All are familiar with the anemic appearance, lowered vitality, weakness

and marked susceptibility to disease of those who habitually live in cellars or darkened houses.

Likewise those who have served in the tropics have observed the deleterious effect of prolonged tropical service—or exposure to heat and light.

A golden mean between exposure to the destructive direct sun-ray and darkness is desired, in other words a light not too intense and not too dark is needed.

Excessive illumination may produce conjunctival discomfort, retinal hyperesthesia, erythropsia, and "after images," if not worse condition.

Likewise eye-strain is apt to result from working in too subdued light.

The effort should be to have a diffuse light which will not necessitate frequent rapid accommodations to varied intensity of light.

Light should not flicker and should be without glare.

White paper reflects 80 per cent. of light, while blue green reflects only 12 per cent. In other words blue green absorbs 88 per cent. of light. Obviously a blue-green room will be a dark room while a white room will be a light room, as it absorbs only 20 per cent. of the light.

The color of the walls, then, is of much importance in attaining a maximum of illumination in a room. The prejudice against the use of green in coloring wall paper because of arsenic is said to be unwarranted since the introduction of the aniline dyes.

Perhaps the most ideal room for reading or study is a room with a white ceiling barely tinted with yellow, this color extending to the picture moulding. Walls should be greenish yellow by natural light. If the room is sunny the color should tend toward green, if shady room toward yellow.

If necessary, as in offices, a darker dado of the same colors may be used. The trim should be light. Window shades are necessary, else there will be areas of too great illumination.

At night or in spaces where natural illumination is inadequate or absent, artificial lighting becomes a necessity. This may be direct or indirect.

Direct illumination is that which comes from a visible source; while indirect illumination is that which results from placing the lamps behind a screen on the walls near the ceiling, the light being thrown upon the ceiling and reflected downward. This method gives

a soft diffuse light and prevents retinal irritation caused by looking at numerous bright points, or lamps.

All satisfactory artificial illumination should be:

1. Of sufficient intensity;
2. Not too intense;
3. Should consume no O, or a minimum;
4. Should give off a minimum of noxious gases;
5. Should not be composed of harmful rays in dangerous amount;
6. Should be of steady unflickering, unstreaked character, resembling daylight as much as possible;
7. Should be economical;
8. Should not be dangerous.

Generally speaking, illumination should be proportionate to the special needs of a given case, *e.g.*, the amount of light necessary for comfortable reading would be unnecessarily great for illuminating an ordinary passageway.

Illumination by candles and lamps is necessary where gas, acetylene, or electricity are not available.

The vitiating effect of candles or lamps upon the atmosphere of a confined space is very great, although the ill effects upon the eyes are less than those produced by the more powerful illuminants.

Electricity is the principal illuminant in use aboard ship.

Gas so generally used in cities is a mixture of several gases, is of moderate intensity depending upon the variety of burner used; it rapidly consumes the oxygen in a confined space; gives off roughly one-half its volume of CO_2; does not give off a large amount of harmful rays; tends to be unsteady, especially in open burners; is moderately expensive; and is very dangerous to life if through accident the gas escapes into a living space, or through carelessness or ignorance is "blown out."

Electricity is unquestionably the best illuminant provided certain precautions be taken.

In photometric work the candle power is a unit employed and is defined as a sperm candle six of which weigh 1 pound and which burns 120 grains per hour. This rather crude standard is being replaced by the International candle which = 1 pentane candle (under normal atmospheric conditions) = 1 bougie decimale = 1 American candle = 1.11 Hefner candle = 0.104 Carcel lamp.

A foot candle is a unit which represents the intensity of light given by one candle power at 1 foot distance. Intensity varies inversely as the square of the distance.

It has been found that for ordinary reading a maximum of visual acuity is attained with an illumination of 1½ to 2 foot candles.

So it would appear that 2½ foot candles illumination is sufficient to allow for the inevitable deterioration of the lamp.

Of course this degree of illumination will be unnecessarily great in halls, storerooms, etc.

The lamp should be covered by some preferably clear glass shade which will not permit the filament to be seen, and which will at the same time diffuse the light. Perhaps the "Holophane" shade is best. These are of various patterns.

Of the various forms of electric lamps on the market the tungsten is most economical in current consumption, powerful, and has the longest life. Owing to the frangibility of the tungsten filament, especially when cold, its general use aboard ship has been found practicable only by using a spring socket to prevent the many jars, concussion from gun fire, etc., to which it is subjected.

In order to get the maximum of efficiency from an electric lamp it should be placed vertically on the ceiling as there is loss of light in having the lamp placed close against a wall: Its horizontal distribution is greater.

On board ship air-ports, hatches, and prismatic "dead-lights" give natural illumination by day. Certain parts of ships are not reached by daylight, hence artificial illumination is employed day and night.

All forms of artificial illumination have practically been discarded for the electric light which has proved a godsend to the sailor.

Good light and no atmospheric vitiation mean much to him.

Generally the artificial illumination employed aboard ship is obtained from the incandescent electric lamp.

The arc lamp has been used in the fire-room of some of the ships, but has been discarded because of:

(*a*) Shadows (not a diffuse light);

(*b*) Intensity of illumination given from the uncovered globe when viewed by the eye; and

(*c*) High proportion of ultra-violet rays.

On some of the newer large ships the Cooper-Hewitt, or mercury vapor lamps have been installed, but are unsatisfactory. While this lamp is very economical, its light contains no red rays, hence the light, instead of being white is very greenish yellow.

"The spectrum of incandescent mercury vapor consists mainly of

three bright lines, one in the blue, one in the green, and one in the yellow" (Ganot).

One authority states that the mercury vapor lamp's spectrum "consists chiefly in two brilliant bands in the blue violet with which is combined ultra-violet spectrum five times as long as in the normal visible spectrum."

Because of its economy, diffuseness, slight shadow production, and soft brilliancy this light is becoming adopted in industry.

The last word has not been said, however, concerning the effect of this ray upon the body processes as a result of living under this light during working hours.

A light which has high oxidizing power, which is productive of ozone, destructive of low animal and vegetable life, and which when concentrated will produce erythema, vesiculation, pigmentation of skin, etc., in the human body, as well as fluorescence of the lens of the eye probably would have some effect upon the metabolic activities of persons constantly exposed to it.

True it is that the ultra-violet ray is a component of white light, but here we find the rays combined with the other rays of the spectrum. It is possible that the effect is negligible, but here is offered an interesting field for investigation.

The human lens absorbs the ultra-violet ray as does glass. It is possible that these rays, although produced in the vaporization of mercury, may be prevented from entering the light leaving the lamp by means of glass of one of the many kinds of which one of the most lauded is a patented glass called "Euphos."

Aboard ship the tungsten filament electric lamp in a spring socket to control the effect of concussion generally fulfills best the requirements of a satisfactory illuminant under varying conditions of ship life.

This lamp, in general, should depend from the deck above and should be covered by a stalactite globe. The filament should be screened. Electric lamps filled with nitrogen are most efficient and serviceable.

The illumination should be at the rate of about 2, not over 3 foot candles upon the normal plane of reading or office work. More delicate work upon darker objects than a white page may require stronger light than 2 foot candles in order to bring out contrasts of color necessary to satisfactory work.

The incident rays should fall from above and preferably over the

left shoulder so that glare from a glossy page may be prevented, and the shadow of the hand does not fall upon the page.

Lamps upon walls or bulkheads are apt to produce discomfort by creating spots of too intense illumination. There is also loss of light from this position. Generally speaking lamps should not be located in haphazard manner, but should be placed with due regard for the needs and comfort of those who will occupy the space.

The tendency has been toward liberality of distribution of lamps on shipboard in so far as efficiency of the plant would permit, but more light on board ship is needed.

Scarcely can it justly be expected that the ambitious young man will fit himself for better things if light is not supplied to him at the times when he has respite from his daily duty.

Intensity of illumination per square inch in candle power is:

Carbon filament	300–375
Tungsten	1000
Cooper-Hewitt	17
Nernst	2200

Maximum intensity borne by the eye without ill effect is 4.25 candle power.

Clear glass absorbs of light	10 per cent.
Holophane	12 per cent.
Ground	25–60 per cent.
Milky	30–60 per cent.

The useful life of filaments in electric bulbs has been found to vary greatly, depending upon the material of which the filament is made and its preparation. The useful life of a carbon filament is 450 hours, while that of the tungsten filament is 1000 hours.

In tropics men should have protection from extreme heat as well as intense light. The researches of Aron indicate that the former is the more important.

CHAPTER XI

FOOD

Perhaps no essential to the efficiency of a fighting force has received so little attention in detail as its food. Want of proper food broke the power of Napoleon's army in Poland in 1806. It led to his retreat from Moscow in 1812. It caused disaster to the British in Crimea, and hastened the fall of Port Arthur. Eight thousand Russians were in hospitals alone in Port Arthur when the fortress fell. Most of them were sick of scurvy, a preventable disease due to improper feeding. Had they been well fed and equipped these 8000 men could have delayed for a long time the surrender of the fortress.

This need of rations has been a potent factor in shaping the world's destiny, and nations have fallen for want of proper food for their troops. The great European war now in progress ultimately may be terminated because of similar need.

In navies this want has been greatly accentuated and naval fighting forces, enervated by hardship and scant food allowance, have been compelled to strike their colors to a better-fed foe.

The improperly fed man suffers not alone the discomforts of starvation, but he falls easy prey to infectious disease and readily succumbs because of his lowered resistance and vitality.

So well recognized is the foregoing that the legislators of the countries having mercantile marines have enacted laws which prescribe a minimum of nutritious food per man, below which minimum avaricious ship owners and masters may not go without rendering themselves liable to the law.

First, it is necessary to determine what is a proper food and then consider its preparation.

A food to meet all requirements must:

1. **Contain** sufficient of the **elements:**

Nitrogen	Magnesium
Carbon	Sodium
Hydrogen	Calcium
Oxygen	Potassium
Phosphorus	Chlorine
Sulphur	Iron

to maintain body weight in a state of health and to compensate for tissue oxidation incident upon body processes and work performed:

2. It **must be palatable** and in such chemical combination as to be metabolized readily;

3. It **must be of sufficient bulk** to stimulate intestinal activity, and yet be not too bulky;

4. It **must be free of poisonous substances** and **disease-producing organisms;**

5. It **must be in sufficient quantity available** for use, its nature being governed by the locality;

6. It **must be** in quantity and quality **proportionate to** the character of **work** to be done.

Food for man must contain the various elements mentioned and is chiefly composed of nitrogen, hydrogen, carbon and oxygen. In combination with these or as condiments the other elements are supplied. Their quantity is small but their presence is necessary to man's well-being.

More clearly to illustrate the relation of the various foods to the human body, let it be assumed that the body is a power plant engaged in furnishing power for its effort, thought, and body processes. This plant has a large furnace generating the necessary heat. A furnace in operation consists of a grate and framework in which the fuel is being burned—heat is being generated.

The furnace itself corresponds to the nitrogenous portion of the human body. The integrity and constant repair of the furnace are necessary to the proper performance of its functions; so with the nitrogenous factor of the human body, and unless we keep this human furnace in a proper state of repair and efficiency by constantly adding nitrogenous or proteid foods the human furnace will collapse.

Again if fuel is not put into the grate of the furnace and kept burning the power plant will lie idle and be impotent. Enough fuel must be supplied in combustible form in order that the activities of the power plant may be maintained. Excess of fuel clogs the fires and prevents free combustion. The flames are smothered in an overwhelming mass of partly burned fuel and ash. So with man. If into our human furnace we do not put sufficient combustible fuel the activities of our human power plant will not be maintained at a normal degree of efficiency. If too much is supplied the body's functions are impaired. Instead of wood and coal our human furnace burns carbon, in form of carbohydrates and fats.

Summarizing, we need nitrogen (as protein) for our body structure (of the furnace) and we need carbon (as fats and carbohydrates) to burn in our furnaces and supply energy to our bodies.

It is remarkable that in utilizing nitrogen for tissue building and carbon for fuel, both elements must be in combination with hydrogen and oxygen—the nitrogen being supplied in the proteid molecule and the carbon in fats and carbohydrates.

For the nutrition of the human body six essential substances invariably are necessary:

1. Protein;
2. Carbohydrate;
3. Fat;
4. Salts;
5. Vitamines;
6. Water.

1. Proteins.—Proteins are substances which contain nitrogen, in addition to carbon, hydrogen, and oxygen, and are divided into (*a*) superior proteins, and (*b*) inferior proteins.

(*a*) **Superior proteins** are of animal origin. Milk, meat, eggs, and fish may be regarded as types of this class, and are more rapidly digested than

(*b*) **Inferior proteins** (vegetable) which are found in the protein content of bread, beans, and maize.

The proteins of potato and rice are intermediately placed between the superior and inferior types.

Thomas has shown that the following daily allowances of protein are necessary to prevent protein loss by the body:

Meat protein	30 grams
Milk protein	31 grams
Rice protein	34 grams
Potato protein	38 grams
Bean protein	54 grams
Bread protein	76 grams
Indian corn protein	102 grams

These figures show us that it is necessary to eat 3.4 times as much protein from maize as from meat if one or the other of these substances were the sole source of the nitrogen supply necessary for the body's needs.

The minimal intake of protein varies in the same individual with

conditions of work, temperature, etc. Chittenden has placed it at from 30 to 80 grams. In addition to repairing the wear on the protein tissues of the body, protein diet increases heat production. The disinclination toward meat diet in the tropics and in summer in temperate latitudes is Nature's effort to lower our heat production. It has been said that a well-cooked beefsteak is the best dietary fortification against cold weather. The diet of the Eskimo consists principally of protein and fat. He requires little carbohydrate to enable him to withstand cold.

Both types of protein, superior and inferior, are heat producers, so that a varied diet is possible without reducing the protein intake below permissible minimum.

Proteins supply heat, energy and repair to the tissues while carbohydrate and fat supply energy, potential or actual.

American physiologists regard ½ gram of protein per pound of body weight as the necessary daily allowance. Excess of protein taken as food is burned as fuel or eliminated in the feces. Protein as such is not stored. A part of it may be transformed into fat and stored as fat. Protein, animal or vegetable, is necessary to life.

Protein must be taken in the body in considerable quantity in order to maintain a nitrogen equilibrium. Experiments prove that it is necessary to ingest at the very least three times the amount of nitrogen actually normally excreted during a starvation diet, before equilibrium is established.

Proteins are believed to be utilized (*a*) as actual structural protoplasm, and (*b*) as a circulating protein available for tissue building or oxidation.

Protein is believed by some to be convertible into glycogen and stored in the liver. Also there is evidence to base opinion that protein may be converted into fat in the body and stored as such.

From the foregoing it will be seen that the body ingests much more nitrogen as protein than it metabolizes. The excess of waste of protein metabolism is urea.

2. Carbohydrates.—Man's food includes carbohydrates of four kinds:

(*a*) Monosaccharids (glucose, levulose, mannose, galactose);
(*b*) Disaccharids (cane sugar, milk sugar, maltose);
(*c*) Polysaccharids (starch, glycogen, dextrose);
(*d*) Pentoses (in fruits and nucleic acids).

The first class may be absorbed without digestive change, and is desirable in food in as great proportion as is assimilable and acceptable.

The principal source of man's carbohydrates is starch. All starches and sugars are converted into glucose in the body. Milk sugar is the only carbohydrate derived from animal source.

Carbohydrate ingested in excess of immediate needs for actual energy is converted into fat and stored in the body. Not over 500 grams daily of carbohydrate should be eaten. More than this is unnecessary and tends toward fermentation and digestive disturbances.

Carbohydrates are fuel for combustion and energy production. Their oxidation results in production of CO_2 and water. Excess of carbohydrate is converted into glycogen and stored in the liver, especially, and in other organs and tissues, ready to be discharged into the circulation when required. Some carbohydrate may be formed in the tissues by an excessive protein diet.

3. Fats.—Fats are taken into the body as such. Some of the carbohydrate of food is converted into fat and a portion of the proteins of food or of body tissue may be converted into fat.

A diet poor in fat tends to produce nutritional disorder, especially in children. Excess of fat above body needs is stored or eliminated as feces.

So much as 200 grams of fat may be eaten daily and only 2 per cent. will appear in the feces, the remainder having been utilized.

Fats ingested are either oxidized and converted thus into energy, or else are stored in the body as fats. It is stated that 82 to 92 per cent. of the excess of fat in a diet can be stored as fat.

When fat is stored it is of the same kind as that ingested even though it is different from the usual fat of the animal, *e.g.*, experiment shows that the melting point of the fat of a dog is about 20°C., but a continued excessive diet of mutton fat, the melting point of which is about 40°C. will cause the melting point of the fat on the dog to rise from 20°C. (normal for dog fat) to 40°C. (normal for mutton fat).

4. Salts.—Mineral salts of calcium, phosphorus and magnesium are found in bone. White sulphur, phosphorus, iodine and iron are found in combination in organic molecules in the tissues and fluids of the body. Salts of sodium, potassium, magnesium, and calcium are found dissolved in the body fluids and free of organic combinations.

Taylor has shown that animals fed on a salt-free diet succumb more rapidly than if the diet were one of absolute starvation. The

inorganic salts then are necessary to the maintenance of animal life, although the total quantity of such salts in the body is small and usually can be supplied in the articles of food ordinarily used in the varied diet.

The inorganic substances required by the body are chiefly Na, K, Fe, Mg, P, S, Cl and Ca. These substances as found in the body are in complex organic combination—not free—and constitute about 1 per cent. of the non-skeletal parts. They find their way into the body in the organic combinations with other food stuffs. Generally they are taken in small amount at a time and perhaps the only ones which are not sufficiently found in the foods are Na and Cl, which are added to man's dietary in the form of sodium chloride.

Absence of calcium from a diet results in rickets. The need for iron is well known. Phosphorus likewise is essential.

5. Vitamines are substances of unknown and complex chemical composition. They come from vegetables, but if enough meat or milk is eaten the body will receive the amount of vitamines necessary to growth and health, the vitamines being received from the vegetable kingdom through the milk and flesh of animals which man uses as food.

Hopkins discovered vitamines. Funk regards them as pyrimidin derivatives and considers their presence in food stuffs necessary to the maintenance of proper nutrition.

So far as is known vitamines are divided into two classes:

1. Class A, soluble in fats; and
2. Class B, soluble in water and alcohol, but not in fats.

Class B is believed present in all food stuffs, animal or vegetable. Polished rice, starch, fats and sugar crystals do not contain it. Maize has a large content of Class B. This class appears to be destroyed when the food is cooked in an alkaline medium.

Foods sterilized at high temperature appear to lose their vitamines. For instance, it has been shown by feeding experiments that growth of rats ceased when the animals were fed upon a diet whose fat component was lard, but when butter was substituted for lard the animals commenced to grow rapidly. From this it would appear that the uncooked butter fat contained something which was absent from lard fat which had been heated.

This experiment of Osborne and Mendel bears out the theory of destruction of vitamines by heat.

The vitamine in rice is removed in polishing, and beri-beri is pro-

duced by eating polished rice from which the pericarp has been removed. Eijkmann has been able to produce a similar condition in fowls called polyneuritis gallinorum by feeding polished rice to fowls, and to cure the condition after it has been produced by feeding the polishings to them.

Beri-beri, pellagra, scurvy, rickets and certain other diseases of disordered nutrition may be due to deficiency in vitamines.

Recent chemical research indicates that some ideas concerning certain articles of diet and their food values must be changed; and that improved nutrition will follow a combination of food stuffs based upon more careful study of recent research. For instance, the protein found in peas and beans "is of low biologic value" because of its low assimilability. Hitherto it has been assumed that the high protein content of peas and beans caused these legumes to have great nutritive value.

McCollum was unable to make a ration of plant seeds to cause normal growth in rats and thinks that man could not thrive upon such a ration. However, normal growth and reproduction followed the feeding of a mixture of the same kind of plant seeds *plus the leaves*. The inorganic constituents of the leaf are greater in amount and different in quality from those found in the seeds. Leaves and seed appear to possess a complementary relation to each other in the maintenance of normal growth.

6. Water.—Water is the most necessary of all foods. Atwater and Benedict have shown that the body at rest gives off 935 grams (nearly a liter) daily as "insensible perspiration."

Sixty per cent. of this is from the skin and 40 per cent. by expired air. The remainder of man's output of water is from the various secretions and excretions. In hard labor man may give off 3 to 8 liters a day, and this loss must be compensated by water intake in food and drink. Under normal conditions man should take about 2½ liters of water daily, 1 liter in solid food and the remainder in fluids.

Food values are expressed in calories. The **large calorie** commonly referred to as calorie is a unit which measures the amount of heat required to raise the temperature of 1 kilogram (2.2 pounds) of distilled water from 0°C. to 1°C. under standard conditions of temperature and pressure. In other words it is the amount of heat necessary to raise 1 kilogram of water 1° C.

Oxidation of carbon and fat in the body has been found to yield the same amount of heat that would be produced by these substances in their combustion under conditions appropriate for measuring heat.

Protein is (*a*) partially oxidized in the body, and (*b*) partially lost in the fæces; consequently its heat production in the body is regarded as about 25 per cent. less than in the calorimeter.

The following values have been established for the complete oxidation in the body of the food stuffs named:

1 gram of protein yields 4.1 calories;
1 gram of carbohydrate yields 4.1 calories;
1 gram of fat yields 9.3 calories.

Rubner places the value of a gram each of carbohydrate and protein at 4.5 calories. The acceptance of a lower value (4.1 calories) is safer.

Food is used for growth and upkeep of the body, maintenance of body heat, and for work.

Atwater as a result of experiment concludes that:
A man performing no muscular labor requires 2700 calories;
A man performing light muscular labor requires 3000 calories;
A man performing moderate muscular labor requires 3500 calories;
A man performing hard muscular labor requires 4500 calories.

The fasting adult in a state of rest produces from 1400 to 1700 calories daily depending upon body weight. This heat production is at the expense of body tissue and must be compensated for by the corresponding food value if body weight is to be maintained. In addition to this, food must be taken as fuel to furnish energy for work and for increased heat production in cold weather.

Manifestly the amount of food taken will vary with age, sex, size of individual, work to be done, season of the year, and in certain diseases. Also the proportions of components of the dietary will vary depending upon the climate, locality, racial preference, and availability of food stuffs. For instance, the diet of the Eskimo is principally of fat and protein. That of the Indian in the tropics is principally of carbohydrate.

Taylor states that the Germans living on 20 grams of fat daily are fat-hungry, although they have twice the fat constituent in the diet of the Japanese. They are said to feel more keenly the reduction of fats than of proteins in the diet. The considerable reduction in fat in the German diet has caused the German individual to appear less fat, but the general nutrition does not seem to be below the needs.

The garrison defending Ladysmith were on a diet having a fuel value of 1500 calories per day for several months.

The daily ration of the German prison camps is protein 57 grams; fat 21 grams; carbohydrate 310 grams. This ration has a fuel value of 1720 calories. In contrast with this meager allowance is that observed by Wood and Mansfield upon fifty men engaged in wood chopping in a lumber camp in Maine. These observations were made for a period of six days. The average per capita intake was protein 164.1, fat 387.8, carbohydrate 982.0, having a total heat value of 8083 calories.

It has been shown that 35 calories per kilo of body weight will maintain nutrition for the average size man on light work.

The following is a list of average diets quoted from the authorities indicated

Moleschott

	Grams	Calories
Protein	130	553
Fat	40	372
Carbohydrate	550	2,275
Total calories		3,200

Ranke

	Grams	Calories
Protein	100	410
Fat	100	930
Carbohydrate	240	984
Total calories		2,324

Voit

	Grams	Calories
Protein	118	483
Fat	56	520
Carbohydrate	500	2,050
Total calories		3,053

Soldiers on Active Maneuvers (Voit)

	Grams	Calories
Protein	135	553
Fat	80	744
Carbohydrate	500	2,050
Total calories		3,347

Foster

	Grams	Calories
Protein	131	567
Fat	68	632
Carbohydrate	494	1,825
Total calories		3,024

Atwater	Grams	Calories
Protein	125	512
Fat	125	1,172
Carbohydrate	400	1,640
Total calories		3,324

The average heat value of the above rations is 3045 calories, and about 17 per cent. of this is from protein. The average proportions of the constituents of the diets given by seven recognized authorities are:

Protein	121 grams
Fat	59 grams
Carbohydrate	510 grams

These figures, it will be observed, are slightly in excess of those of Voit which have long been accepted. He gave as an ideal dietary: protein 118, fat 56, carbohydrate 500. However, the difference in caloric value is only 80 calories.

There is a general accord as to the amount of carbohydrate which should constitute the diet of an adult doing moderate work. There is considerable difference of opinion as to the protein intake necessary.

Chittenden, in a test upon soldiers, reduced the protein ration to one-half or one-third and kept the men under observation for some time. After adjustment to the new conditions the body weight was stationary, and the subjects are said to have shown increase in vigor and strength, and no reduction of mental vigor. Hæmoglobin and red cell count remained normal. From this experiment he concluded that the long accepted protein standard of Voit (118 grams) is much too high and should be reduced by about one-half. He states that 50 grams of protein with carbohydrate and fat added to make the total fuel value of 2500 calories is sufficient for the soldier at work.

By experiment Chittenden also has proved that men performing hard muscular work may maintain a nitrogen equilibrium on 6 to 10 grams nitrogen per day × 6.25 = protein. Highly as his work is esteemed, it is impossible wholly to ignore natural inclination in respect of this matter. That men may subsist for several months without loss of nitrogen equilibrium appreciable by present methods is granted, but is it not possible that various proteid secretions (internal included) may gradually suffer, and that while no appreciable change appears in one or ten men—subjects of the experiment—in six months, may not such restriction of the proteid content no less surely work toward gradual deterioration in time of the persons limiting themselves to such restricted protein diet?

The Japanese live largely upon a diet of rice. Rice has a protein content of 8 per cent.—very small percentage. In addition they eat a small amount of fish—also

low in protein, as compared with beef. Why are the Japanese of small stature and can it be that the low protein diet upon which the Japanese have subsisted for generations is responsible in part at least for the shorter average duration of life in Japan? While occasional instances of longevity are seen, the visitor to Japan is at once impressed with the paucity of aged persons.

Again the food of India is largely a diet having low protein content. These people are of our own Caucasian, or Indo-Germanic race. Compare the achievement of the European Caucasian since the Aryan Migration with the slow physical deterioration of the great mass of people of India. This is sad in view of the splendid mentality which is and has been their pride. Is it unreasonable to believe that gradual starvation, deprivation of protein in their dietary, may be at least partly responsible for the lagging behind of this great people who are ethnically our brothers?

The effect of reduction in caloric value of the ration in Germany during the present war has caused a tendency to adopt a protein standard less than that formerly considered necessary, yet the reduction is not so radical as appears to be advocated by the adherents to the low protein theory.

A careful study of available data and of arguments for and against a low protein allowance leads one to believe that **100 grams per day of protein is not an excessive allowance for** the individual of **moderate work,** and that he requires a total fuel value of about 3000 calories.

The **ration of the U. S. Navy** is 142 grams of protein, 192 of fat, and 492 of carbohydrate, giving a total fuel value of 4384 calories. This ration is excellent in quality and is sufficient in caloric value.

Instinct is often a good guide in the selection of food as to quality and quantity. Hard and fast lines cannot well be drawn because the appetite for food is influenced by so many factors. For instance, it has been observed that resting dogs at a temperature of 0°C. will devour with avidity food which in quality and quantity would be partly refused in a temperature of 33°C.

The quantity of food taken must be sufficiently bulky to stimulate the muscle fibers of stomach and intestines to their normal action.

Arctic explorers have found great difficulty in attempting to live upon concentrated food stuffs. One explorer has told the writer of the relief from the digestive disturbances experienced by his party when they commenced to eat the hair of animals in order to give the necessary bulk to the food ingested.

Sources of Food

It now seems desirable to consider foods from a standpoint of their source.

Natural Appearance of Cuts of Healthy Beef

Beef is the most important of any of the meat of flesh foods. To be able to judge of its freshness and freedom from disease is of great practical value. The following colored plates show the appearance of some of the principal cuts of beef in the proper condition for cooking. By comparing the appearance of the meat bought in all markets with these plates it is possible to form a sound judgment of their suitability for consumption.

These seven Plates are reproduced by courtesy of Armour & Co., Chicago

Beef Tenderloin

Beef Sirloin

Beef Ribs—Regular Cuts

Beef Rib—Spencer Cut

Sirloin Butts

Beef Rib

Beef Loin

Excluding water and sodium chloride we may divide our food stuffs into those of:

(*a*) Animal origin; and

(*b*) Vegetable origin.

(*a*) The foods of the first class embrace the flesh of animals, fish, milk, butter, cheese, and eggs.

Meats consist of large proportion of protein, average 18 to 20 per cent., and a negligible amount of carbohydrate. Fat and water constitute the remainder. The percentage of protein is practically a constant, carbohydrate negligible, and the amount of fats and water will vary—more of one, less of the other—lean meat containing more water per pound than fat meat. Obviously pound for pound fat meat contains more nutrient material than lean meat.

Of the various meats used as food beef is perhaps the most nutritious, although mutton is more digestible. The percentage of nutrients in the various meats varies and must be obtained from proper analytical tables.

Meats from the following sources should not be used for human consumption:

1. Animals dead of or killed while suffering from internal diseases, contagions, pyæmia, etc.;
2. Animals killed by overdriving;
3. Animals that have been poisoned;
4. Cows with calf or just after parturition;
5. All putrid flesh;
6. Animals harboring animal parasitic diseases which are dangerous to man.

Carcasses of animals dead of tuberculosis are rejected by the U. S. Government inspectors if there is evidence of a general tuberculosis, but if a localized tuberculous lesion is found and a careful inspection shows that the process is *not* general the carcass may be passed after removal of the tuberculous focus.

Good meat should be red, neither pink nor purple; should have a sweetish odor; should not pit on pressure; should be dry, *i.e.*, should scarcely moisten the examining finger.

The ribs should be pink and covered with pleura, free of adhesion. The flesh should be somewhat elastic and should have a mottled or marbled appearance due to the presence of fat. Dark flesh suggests inflammatory conditions or improper bleeding (sugillation).

If there is doubt as to the freshness of the specimen a skewer or pencil thrust deeply into the flesh, especially near bone or near a joint will bring away with it a putrid odor if the meat is decomposing. Putrefactive changes usually may be detected in the pelvis first.

Just here a word may be said to warn against rejection of meat of good quality which may show a putrefying, foul, grayish moist surface due to improper care of that surface. Often the butcher's knife will remove a cut from the surface and reveal sweet meat of good quality. Again in dry atmosphere a cut surface may be dark and grumous in appearance due to drying, yet it may cover excellent meat.

Beef is bright red, and of quality described above. Bull meat is usually very tough, stringy and not agreeably flavored.

Meat cooked during rigor mortis is tough although it may be tender before and after rigor mortis.

Veal is flabby and pale when compared with beef. Mutton is firm and dull red. Lamb is softer and lighter in color than mutton. Pork is lighter in color, less firm than beef or mutton.

The flesh of birds is not so fat as that of mammals, hence is not so marbled in appearance. Wild birds which have fed upon fish are apt to deteriorate in flavor if kept too long.

Milk.—More disease and death have been caused by milk than by all other food stuffs used by man.

In our country each person consumes 0.6 pint daily, and when we remember how difficult it is to obtain clean milk and the impossibility of procuring sterile milk (without sterilizing); when we remember that this is the only animal food usually consumed by man in its raw condition; when we remember that milk and its products constitute 16 per cent. of our diet in the United States; and when finally we recall that it forms one of the best-known culture media; it becomes evident that the ingestion of milk handled in a filthy manner or accidently infected with a pathogenic organism is very frequent and may be tantamount in effect to drinking an equal volume of laboratory culture of the organism in question.

As milk is the ideal food for babes and children a pure product is desirable. "Top milk" so commonly used for children contains most of the bacteria in the bottle from which it is taken.

Composition.—Milk, a solution of sugar, proteins, mineral matter and fat in suspension, varies in specific gravity from 1027 to 1035.

The complexity of the various components is dependent upon so many factors, diet, gestation, water, assimilation, fatigue, etc., etc., that we shall give the following simple analysis disregarding much of the complexity:

Whole milk contains (cow):

Proteins	3.3 per cent.
Fat	4.0 per cent.
Sugar (carbohydrate)	5.0 per cent.
Mineral matter	0.7 per cent.
Water	87.0 per cent.

The protein content of cow's milk is three times that of human milk and cow's milk contains several (three or four) times the amount of inorganic salts that human milk contains. Usually limewater, cream and sugar are added to cow's milk as may be needed to make it approximate more nearly human milk for consumption of infants.

The Milk Committee of the Board of Health of New York has established three grades of milk:

(*a*) Certified;
(*b*) Inspected;
(*c*) Market milk.

(*a*) Certified milk:

1. Frequent inspections of dairy and analysis of milk;
2. Cows to be healthy as shown by tuberculin test and examination by qualified veterinarian.
3. They must be housed in properly appointed and cleaned stables;
4. Scrupulous cleanliness must be exercised by all persons handling the milk and all must be free of tuberculosis, diphtheria, typhoid, etc.
5. Milk must be drawn so as to prevent contamination, immediately cooled and kept not above 50°F., in sterilized bottles until received by consumer not more than thirty-six hours after it is drawn.
6. Pure water, chemically and bacteriologically, must be used in the dairy;
7. Certified milk must not contain over 10,000 bacteria per cubic centimeter.

(*b*) Inspected milk:

1. Conditions about the same as to process and delivery but not quite as good;
2. Should contain not over 100,000 bacteria per cubic centimeter

(*c*) Market milk:

1. Embraces all milk not included in foregoing specifications.

Adulterations of milk are:

Skimming removes whole or a part of the cream and barring reduction of nutrient fat is harmless to man.

Watering, dilutes and may add pathogenic organisms. This is not done so commonly as formerly.

Thickening, coloring, sweetening and *alkalinizing* are done to increase marketable quality of butter.

Chemicals are prohibited but boracic, salicylic and benzoic acids and formaldehyd have been used.

Bacteriology.—Bacteria do not pass through the udder usually unless it is involved in some disease process. They grow up the lacteal ducts, which are infected as result of the drawing back into the ducts of the last drop of milk when the pressure upon the teat is released.

Milk frequently shows a higher bacterial count than sewage.

Diphtheria, anthrax, scarlet fever, erysipelas, typhoid fever, tuberculosis, Malta fever, milk sickness, septic sore throat, foot-and-mouth disease, cholera, and gastro-intestinal infections all are conveyed at times by infected milk.

Milk-borne epidemics of disease are explosive, tend to follow milk routes, occur among users of milk, occur among people in good circumstances (able to buy milk), and usually more women and children are attacked.

Schüder has collected from literature statistics of 650 typhoid epidemics the supposed causes of which had been reported; of these 110 were due to milk, 462 to water, and 78 to other agents.

Since typhoid fever, tuberculosis, diphtheria, scarlet fever and dysentery commonly are borne in milk, steps should be taken to prevent these infections.

Three methods of treating milk are in use looking toward the prevention of diseases which might be borne in raw milk. They are:

1. Boiling;
2. Pasteurization;
3. Buddeizing.

1. **Boiling.**—Janet E. Lane-Claypon has shown that boiled milk suffers little loss of nutritive value and her feeding experiments on a large scale indicate the desirability of boiling milk, thereby insuring sterilization.

Variot states that among 3000 children fed on milk heated to 103°C. no case of infantile scurvy was seen. Bresset reports over 2000 children fed on sterilized milk without apparent ill effect. These feedings

on a large scale indicate that marked malnutrition does not follow the feeding of milk made safe by boiling.

All milk on board ship should be boiled before using, and after boiling should be kept on ice if it is not to be used immediately. Boiled milk should be kept in the container in which it is boiled until ready to be served.

2. Pasteurization.—Pasteurization is a process in which milk is exposed to temperatures intended to destroy pathogenic organisms but not sufficiently high to produce sterilization.

Pasteurization is accomplished by:

(*a*) The holding method;
(*b*) The flash method.

(*a*) *The Holding Method.*—In this method milk is exposed to a temperature of 60° to 65°C. for a period of twenty to thirty minutes. It is claimed that the specific causes of tuberculosis, typhoid fever, diphtheria and dysentery are destroyed when milk is held at 60°C. for 20 minutes. Some dairies expose milk to this temperature in bulk, others have facilities for filling the bottles, pasteurizing the milk in them and then capping the bottles. This is the ideal method of pasteurization.

(*b*) *The Flash Method.*—This method consists in raising the temperature of milk to about 175°F. for a moment and then chilling it rapidly. The method is unreliable.

After pasteurization the milk should be chilled as rapidly as possible and kept on ice, else rapid decomposition will take place.

W. W. Ford and the writer, after an examination of seventy-eight specimens of Baltimore market milk showed that heat resistant spores of aerobic and anaerobic bacteria may survive pasteurization as Flügge first noted.

They showed that the organisms surviving are capable of causing disagreeable and unwholesome changes in milk, converting it from a nutritive food into an undesirable if not dangerous article of diet.

These changes take place in milk heated to any temperature from 65° to 100°C. and held there for thirty-five minutes, then kept at any temperature from 22° to 37°C., but not at that of the ice-box, 4° to 6°C.

They further showed that spores of the bacteria causing these changes survive in milk kept for long periods (four to six weeks) and can cause the same changes in the milk kept on ice when transferred to a higher temperature.

Milk heated to any temperature from 60° to 100°C. should be kept on ice, as heated milk is far more apt to decompose than raw milk.

The lactic acid organisms are killed in milk which is pasteurized. They cannot inhibit the growth of the gas bacillus and prevent the decomposition resulting. Pasteurization should not be depended upon if milk is to be kept for even two days.

Of 129 specimens of milk examined in their study most of the specimens had been commercially pasteurized before being subjected by them to the temperatures mentioned (65° to 100°C.).

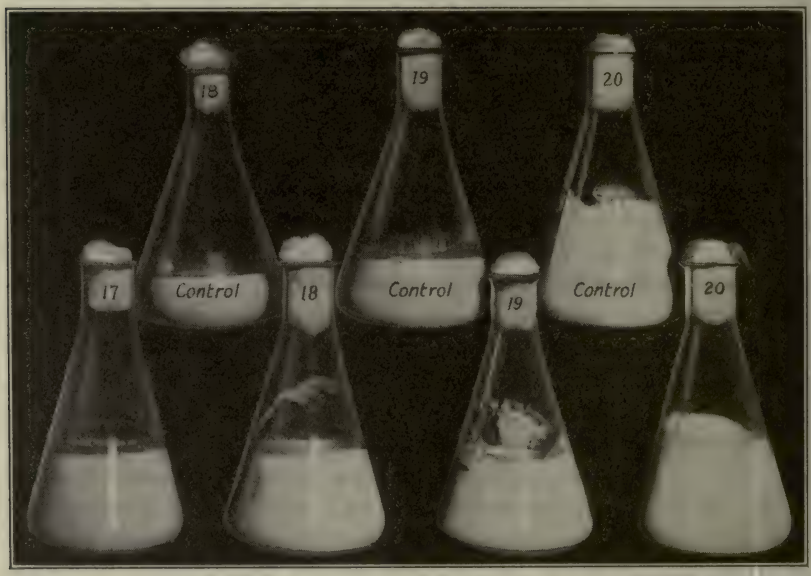


FIG. 29.—Raw controls and flasks of heated milk show no change after being kept in the ice-box for six weeks.

Ford has shown that the spore-bearers which survive pasteurization are capable of producing a substance in the milk highly toxic for experimental animals when injected into them.

The writer found that spores of *B. aerogenes capsulatus* survived in 90 per cent. of 30 specimens of Washington market milk which had been heated to and held at a temperature of 85°C. for thirty-five minutes.

The accompanying figures illustrate the action of the spore-bearers which survived. The flasks in the upper row in each figure show the

raw controls. In Fig. 29 the flasks were kept in ice-box (4° to 6°C.) and no change is noted in either the raw controls or the flasks which had been exposed to 85°C. for thirty-five minutes (lower row).

Fig. 30 shows specimens of the same milks which had been kept for twenty-four hours in a temperature of 37°C.

The raw controls are scarcely if at all affected while the lower row shows decomposition of the clot, accompanied by gas production and foul odor in the flasks which had been heated as described above. The

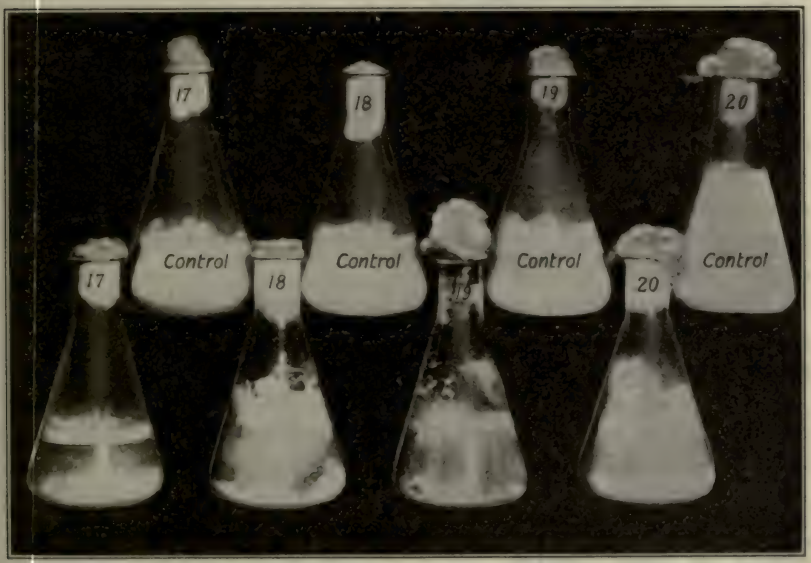


FIG. 30.—Milk similarly treated, but kept at body heat. Controls show little change at end of 24 hours. The heated milk has undergone explosive decomposition with gas formation. In the third flask, lower row, the cotton plug has been blown from the mouth of the flask.

explosive decomposition commenced to be evident within six hours. These figures illustrate well the importance of cooling pasteurized milk rapidly and keeping it on ice until used.

3. Buddeizing.—This is a process recently employed along the Baltic Sea.

A small quantity of peroxide of hydrogen is added to the milk which then is subjected to a temperature of 122°F. for twenty minutes. The heating drives off the peroxide, the taste is unim-

paired, and the process is said to be more effective than commercial pasteurization.

Boil all milk intended for use on board ship. Skim milk is substantially the same as whole milk except that the *fat* has been removed as cream. Cream it will be remembered contains over 18 per cent. of fat.

Buttermilk and skim milk are practically the same from a view point of nutrient content, skim milk containing 5 calories of energy per pound more than buttermilk.

Butter.—Butter should contain at least 82.5 per cent. of butter fat in order to comply with standard set by Congress. Later acts of Congress permit addition of coloring matter.

Butter is produced by agitation of milk until the fat globules in suspension coalesce into granules, are removed, and "worked" to free the butter of buttermilk and water. Generally salt is added to flavor and preserve it. Butter readily absorbs odors, and rapidly becomes rancid at room temperature owing to decomposition of curd which cannot wholly be worked out.

Naturally the more water that butter can be made to hold the greater the profit to the dealer. Unscrupulous persons in some sections add gelatine, or glucose.

Both substances have the quality of absorbing moisture, consequently butter to which they are added will retain more water than otherwise. Such substances are called butter "expanders." Butter may carry disease. Twenty-two per cent. of specimens examined were found to contain tubercle bacilli. Typhoid bacilli may live in butter for three months.

"Process" butter is a butter which results from the melting, washing, coloring and rechurning of butter which has undergone changes, become rancid, etc. This rancid butter is collected from various sources, treated as above and is sold as process butter or as "butter."

Oleomargarine is sometimes offered as a substitute for butter. Oleomargarine is made by rendering fresh beef fat (rancid fat will not make "oleo") in order to separate the fat from the tissues. The liquid fat is then drawn off and kept at 80° to 90°F. for a while, at which temperature the stearin solidifies, and is separated from the oleo-oil which is churned with milk or with milk and genuine butter to impart the butter aroma, after which it is sold on the market as oleomargarine. It is as nutritious as an equal volume of butter, is cheaper, is purer

(especially if it is not churned in milk), and little deserves the disrepute into which it has been thrown by the vendors of butter who realize that they must do all in their power, else oleomargarine may lessen their sales, especially to those who must count their pennies. In its manufacture oleomargarine must be heated to a temperature that kills any bacteria.

Cheese.—Cheese is the product of solidifying milk or cream and ripening same by coagulating the casein either with rennet or lactic acid. It must contain not less than 50 per cent. of milk fat.

Cheese is made from milk of cows, goats, ewes, mares, etc. The milk is heated to about 80°F., then the rennet is added, and after several hours the whey is drawn off, the curd is then put into a press and "subjected to gradually increasing pressure" until most of the whey is forced out of it.

It is then put away to "ripen." This process may require several months or years.

The ripening process will not progress thoroughly unless the proper bacteria are present, and unless the conditions favorable to their growth are present; *e.g.*, hyperacidity will inhibit, etc.

Eggs.—Eggs form a common article of food either as hen's eggs, eggs from other fowls, roe, etc. As certain fish are apt to be poisonous at spawning time, and as the poison appears to be concentrated in and about the reproductive apparatus of the sexes, roe of fish of unknown character should be taken cautiously. The roe of the garfish is said to be poisonous. Investigations are now in progress to prove or disprove the truth of this assertion. If poisonous the roe is unsuitable for making caviar.

Ordinarily, by "eggs" we mean those of hens. As marketed they are of all qualities, from really fresh eggs to those which are rotten. When fresh the egg is an excellent food material, but when of poor quality it readily may cause disorder or disease.

Genuine fresh eggs may be preserved in cold storage, brine, lime-water, sawdust, paraffin, petrolatum, or liquid glass (shellac). Most of these agents close the pores of the eggshell and prevent the entrance of putrefactive or pathogenic organisms.

It must be remembered that the eggshell is porous like a Berkefeld filter rather than impervious to water like glazed porcelain. In other words *moisture may be absorbed through the shell*, and if water enters by capillary attraction, *germs may also*. An egg placed in a solution

of methylene blue will show the blue on the inner side of the shell in a very short time.

From what has been said it is evident that eggs should not be permitted to lie in wet places, or in the putrefying remains of broken eggs.

Especially pernicious are those mixtures of so-called fresh eggs, cracked eggs, decomposing eggs, etc., which are called "egg mixture" and are largely used by bakers. Serious attacks of gastro-enteritis have resulted from ingestion of food prepared with this mixture, *B. botulinus* being the chief cause of the sickness.

Vegetable Foods (Harrington's classification):

1. Farinaceous—cereals, legumes;
2. Farinaceous preparations;
3. Fatty seeds (nuts);
4. Vegetable fats;
5. Tubers and roots;
6. Herbaceous articles ("vegetables");
7. Fruits used as "vegetables;"
8. Fruits in the narrower sense;
9. Edible fungi;
10. Saccharine preparations.

1. *Farinaceous.*—(*a*) Cereals generally are wheat, corn, rice, rye, oats, barley and buckwheat; all starchy.

They are all largely of the same composition, although the constituents vary in amount. Wheat is of great importance in that it yields flour.

Flour contains:

Moisture	12.0 per cent.
Proteids	11.4 per cent.
Ether extract	1.0 per cent.
Carbohydrate	75.1 per cent.
Ash	0.5 per cent.
	100.0 per cent.

White flour consists of the cleaning and grinding of the grain and bolting removes the bran.

Graham flour is the result of grinding the cleaned whole wheat—no bolting.

Good flour should be slightly "gritty" when between the teeth; when taken into the hand and squeezed the mass should retain its shape upon release of the pressure and should collapse when shaken; should have slightly sweetish taste; should have no musty odor; and should present no evidence of mould, or weevil.

Corn is chiefly of value to man as a food material because of the meal derived from it.

Some corn is eaten in the ear. Popcorn is another form in which corn is consumed. Hominy, samp, and meal are also forms of prepared corn.

Hominy is the crushed grain less its hull, which is removed by soaking. *Samp* is the whole kernel with the hull and germ removed. The meal is made by grinding the grain and sifting it. If the germ be included, however, the meal is apt to decompose rapidly.

Corn meal contains (Wiley):

Moisture	12.57
Proteins	7.13
Ether extract	1.33
Total carbohydrate	78.36
Ash	0.61

From this analysis it is seen that corn meal is very nutritious.

Rye.—Flour made from rye is more like that of wheat flour than that from any other cereal. Its gluten is not so good as that of wheat flour, hence rye bread is not quite, but almost so good, as bread from wheat flour.

Barley is used in making beer and as a food for invalids. Recently its use is becoming more general.

Oats are much used as a food for man. As they contain no gluten they cannot be made into bread readily. More fat is contained in oats than in any other cereal.

Oatmeal is a most common article of diet and contains much nutriment.

Rice.—No cereal is so poor in fats and proteids as rice, but none is so rich in starch.

It is digestible and highly nutritious. It is estimated to be the principal food of one-third of the human race.

Buckwheat is used chiefly for cakes. It has high protein content. No gluten is contained, hence it cannot be made into bread.

(*b*) *Legumes.*—This group, consisting of beans, peas and lentils is characterized by a very high protein content—more per pound than meat. However, the protein is not so digestible as that of meat.

Peas are nutritious as the following analyses indicate:

Dried peas:

Protein	22.85
Fat	1.79
Starch	52.36
Fiber ash and H_2O.	

Green peas:

Proteid	7.0
Fat	0.5
Carbohydrate including fiber	16.9
H_2O	74.6

Canned peas are chiefly water (85.3 per cent.), hence contain little nourishment:

Proteids	3.6
Fat	0.2
Carbohydrate	9.8

One pound can of peas then would contain:

	Ounces	Grams	Calories
Proteids	0.576 =	17.91 =	71.64
Fat	0.032 =	0.99 =	8.91
Carbohydrate	1.768 =	54.99 =	219.96
			300.51

If one were to attempt to meet the requirements of the Voit dietary by subsisting on canned peas it would be necessary to eat 56 lbs. of canned peas per day!

(118 grams proteid = about 7 pounds canned peas
56 grams fat = about 56 pounds canned peas
500 grams carbohydrate = about 8 pounds canned peas.)

Beans.—Dried beans are very nutritious, some varieties containing almost 25 per cent. of proteid and almost 50 per cent. of starch.

Naturally the dried beans are more nourishing, as the string beans contain 89 per cent. water.

Lentils.—Lentils are said to be "the most nutritious of the legumes." Lentils contain:

Proteids	25.70
Fats	1.89
Carbohydrates	53.46

They deserve wider use as a food stuff than has been accorded them in this country.

2. *Farinaceous Preparations.*—*Sago*, *tapioca* and *arrowroot* are used chiefly in diets for invalids, or in puddings, etc. Sago is obtained from the pith of the sago palm, which is ground, placed in water, and strained.

Tapioca comes from the root of the "manihot." The starch, extracted with water, is heated and forms masses which are seen in the market as transparent grains.

Arrowroot is a starch obtained from the root of "maranta." It is ground or grated and dried, forming a bland powder about like corn starch, which frequently is used in its place.

3. *Fatty Seeds.*—Nuts have high nutritive value but contain no starch. Almonds, cocoanuts, walnuts, peanuts, chestnuts, are commonly used.

Cocoanuts	= 70 per cent. fat
Walnuts	= 60 per cent. and 16 per cent. proteids
Peanuts	= 45 per cent. and 30 per cent. proteids

4. *Vegetable Fats.*—Under this class come olive oil, cotton seed oil, and peanut oil.

Olive Oil.—Olive oil is obtained by pressure from the mature olive.

Virgin oil is made by pressing (first pressure) mature selected olives.

Pure olive oil should contain 100 per cent. of fats. It is used in salads and cooking.

Cotton Seed Oil.—Cotton seed oil is obtained by pressure from cotton seeds. It is nutritious and cheap, and is used as a substitute for olive oil.

Its chemical composition shows it to be an excellent article of diet and cheap, therefore it is deserving of wider use than it has.

5. *Tubers and Roots.*—Under this class come potatoes, sweet potatoes, artichokes, beets, carrots, turnips, and oyster plant.

Potatoes consist chiefly of starch from a nutrient viewpoint, and

contain about 18 per cent. of carbohydrate. Sweet potatoes contain 27 per cent. of carbohydrate.

Potatoes contain potassium salts. When potatoes are soaked and boiled in water these salts are lost, so is the small amount of proteid which is in solution in the potato. Consequently potatoes should be steamed—not boiled—with skin intact. They should never be soaked in water and then boiled.

The potato is a member of the belladonna family, and its leaves are poisonous. Also solanin which is found in the sprouting potato is quite poisonous.

The Jerusalem artichoke from Italian girasole (sunflower) contains about 15 per cent. sugar and twice the proteid content of potatoes.

Turnips, carrots, oyster plant, parsnips, beets, etc., are all of generally about the same food value in that they supply bulk and some nutriment (about 1.5 per cent. proteid; 0.5 fat and 5 to 17 per cent. carbohydrate).

6. *Herbaceous Articles.—Celery, lettuce, cresses, cabbage, onions*, etc., contribute mineral salts to the diet, and like the roots and tubers are more or less antiscorbutic.

7. *Fruits as Vegetables.*—Tomatoes, pumpkins, squash, egg plant, cucumbers, etc., fall in this class. They supply salts, but while adding to our dietary they are chiefly water (90 per cent.).

8. *Fruits.*—Apples, pears, cherries, plums, peaches, oranges, grapes, melons, and berries are all about of the same nutritive value—mostly water, some sugar, and fruit acids.

Bananas and figs are somewhat better—they contain much higher percentage of sugar (banana 20 per cent. and fig 50 per cent.).

9. *Edible Fungi.*—Mushrooms and truffles contain about 12 per cent. nitrogen; hence are of food value. Poisonous varieties must be avoided.

10. *Saccharine Preparations.*—Cane sugar, maple sugar, glucose and molasses are all of great food value, glucose less than the rest. They are carbohydrate food; hence are energy producers.

Honey.—"Honey is a concentrated solution of sugars," 73 per cent. Hence contains much carbohydrate. Honey from plants which are poisonous to man may prove toxic. Numerous instances are recorded where people have been poisoned by eating honey from such source. Honeys made from yellow jasmine and rhododendron are poisonous.

Confectionery.—Dyes and terra alba are adulterants used in con-

fectionery. It is reported that ground glass is being added by Germans to candy intended for use by their enemies.

Alcohol.—Alcohol stimulates to great and sudden effort. Forty minutes after ingestion depression occurs. It causes dilation of peripheral vessels with rapid heat dissipation, hence is dangerous in cold weather. Is not good food. It has little use in medicine.

Canned Foods.—Meats, milk, cheese, and vegetable foods are preserved in cans.

These cans should be carefully handled. Badly dented cans may have small punctures.

The top of a sound can should present a slight concavity which results from sealing the can while the contents are hot, and the contraction upon cooling. Any can whose top presents a convex surface is "blown" and unsafe, since the convexity usually is due to gases of decomposition of its contents. When the integrity of the can is broken bacterial growth may result in poisoning or acids may be formed which attack the tin on the inner surface of the can and cause tin poisoning.

If there is question of the wholesomeness of the contents of a can, reject at once.

Fish.—Fish constitutes a considerable component of the dietary of sea-going population, and comes to them canned, salt, dried or fresh. If properly dressed and put on cold storage before decomposition commences, fresh fish may be kept indefinitely. Perlzweig and Davies have shown that "fresh fish similar in general character to flounders may be preserved for at least two years without undergoing any important alteration and without materially depreciating in nutritive value."

In some countries fish is almost the sole source of animal protein in the dietary.

There are many varieties of edible fish, including shell-fish. Some fish are constantly poisonous for men, while others are toxic only at certain periods during their lives. Fresh fish require to be handled very carefully, as they tend toward rapid decomposition and production of poison dangerous to man.

Fish diet has been supposed to cause lepra, and to this diet have been attributed qualities which tend toward brain development and great mental strength. It has not been shown that fish-consuming people are unusually susceptible to leprosy, nor

is it recorded that a people whose chief animal food is fish, the Esquimaux for example, are possessed of exceptional brain power.

It seems that these two above-mentioned beliefs, which have been so tenaciously clung to by many, are little more than widespread superstitions.

Flesh of all fishes (and the edible mollusks and crustaceans are included in this term) has a high protein content, but the fat content as a rule is small compared with meat, *e.g.*, beef.

Certain fishes are edible the year round, others are poisonous to man throughout the year or during certain seasons only. Again some fishes, and especially mollusks, are toxic to man only in certain localities.

The flesh of freshly killed fish is much paler in color than is that of mammals. It should sink if thrown in the water. Floating is due to gases of decomposition. It should be firm to pressure, of sweet odor, should not present discolored spots, should not be too watery or slimy, and should not readily separate from the bone. The eyes of the fish should not be sunken and of ground glass appearance. The cornea should be clear. Suspect gutted fish unless in ice. Evisceration is presumptive evidence against the freshness of fish. It may have been gutted to prevent decomposition and to enable its keeping. The gills should be fresh and pink and the scales should not separate readily from the skin. Fish in market usually are in ice and have been gutted. While wholesome, the flavor is impaired by the preservation in ice.

In examining a fish seize it by the tail and shake it sharply near the examiner's ear. Crackling due to separation of vertebral segments indicates that the fish is not fresh.

Some fish, *e.g.*, flounders, have soft meat. Fish from clear streams or clear sea and sandy bottom are apt to have flesh of better texture than those from muddy water and muddy bottoms.

Fish from great depths are repulsive in appearance and undesirable because of the quality of their flesh. All shell fish decompose rapidly, hence should not be kept.

Naturally dried fish contains less water and more protein per pound, but it is not so digestible as fresh fish. It is much used and supplies considerable protein.

Canned fish is generally preserved in tins. These should not be opened until ready for cooking, otherwise poisoning may occur. Stannates may cause it.

Fish caught in the tropics should be kept alive if possible until time for their preparation for cooking. If this is impracticable they

should be eviscerated and kept in the shade in sea water if better facilities for care are not available. Not more than six hours should elapse between the death and cooking of fresh fish in the tropics unless the eviscerated fish are placed in cold storage.

No fish should be eaten which are not known to be fit for food. The sojourner in the tropics will do well to inquire of the natives as to the edibility of fish with which he is unfamiliar. It is a fairly good, but not infallible rule, that poisonous fishes are repulsive in appearance. Possibly Nature intended this sense of repulsion to be a guide to man in the choice of fish for food.

In certain tropical waters large sea turtles may be eaten. They make excellent soups, and if properly cooked the meat may be used, though it is apt to be tough.

At times, however, food stuff from the sea is kept for some time; for instance in Tahiti the writer saw a sauce made from a variety of shell fish, the flesh of which is pulpefied, mixed with lime made from burnt coral, placed in a bamboo joint over the top of which was tied a banana leaf, and allowed to stand about six weeks. This mixture was used as a sauce upon raw fish, and no ill effects are known to have followed the eating of this delicacy.

On the Bering Sea coast of Alaska some of the natives bury freshly caught salmon in the ground and exhume it after the expiration of an interval of time which experience has taught them is sufficiently long to ripen the fish for their palates. This partially decomposed flesh is much relished by them and appears to produce no ill effect. The same natives eviscerate salmon and hang it up to dry in the sun to supplement their winter food supply.

Mussels, clams, oysters, and lobsters are used as food. Clams and oysters are more commonly used because of their quantity and availability.

Oysters are frequently used for food. While tasty and palatable their food value is extremely small.

Care should be exercised as to the source of oysters eaten raw. If the oyster beds are in proximity to the outfall of large sewers contamination of the oysters may occur, and they may become the carriers of intestinal infections. Outbreaks of typhoid fever have been attributed to oysters from polluted water.

It is the practice in some sections to place oysters temporarily in fresh water shortly before putting them on the market, with a view to make them larger by reason of absorption of additional water. This process, called "fattening," is undesirable in that it lessens the flavor of the raw oyster, and tends toward pollution by reason of the

fact that too commonly the fattening beds are in small streams, the water of which is of doubtful purity.

Oysters purchased in bulk for ships should be purchased "dry," that is, free of their liquor. This fluid may well be supplied in a separate container, as it is a very desirable addition to oyster stew when made on a large scale.

In some localities the oysters possess an undesirable flavor owing either to mineral or organic content in the water in which they grow.

During the summer season oysters are regarded by many people as unfit for food during the months the names of which do not include the letter "r." While the absence of the letter "r" from the name of the month can have no possible connection with the suitability of oysters for food, this rule is not a bad one, because it is particularly during these months whose names do not include "r" that intestinal diseases are most prevalent, oyster beds most liable to pollution, and in addition the oyster is said to be not so palatable at this breeding season. Oysters never should be eaten raw.

Clams, when they are available, form a very common article of diet for the seafaring man. At times their ingestion results in poisoning.

The following entry made by the writer in the Medical Journal of the U. S. S. Albatross at McHenry Inlet, Alaska, September 12, 1900, is of interest in this connection.

An abundance of clams may be found at this place. Captain J. C. Callbreath, proprietor of the salmon hatchery here, informed us that they are excellent and are constantly used for food by him and all persons at his hatchery. As Captain Callbreath has been stationed here for eight years, he is in position to be informed on this matter. Upon hearing that the clams were innocuous, all the messes on board secured a supply of them, and they were eaten raw, fried, steamed, in chowder, etc. Fourteen persons (one officer, three petty officers, and ten of other ratings) suffered to a greater or lesser degree, no one being so ill as to be wholly excused from duty for a day. The two pet cats also suffered, their symptoms being very severe. The symptoms commenced to manifest themselves within three hours after the ingestion of the clams, and in one case persisted for forty-eight hours.

Before detailing the symptoms it may be of interest to state that there has been no change in the water supply, and the messes have used the same water supply for several days. There has been no change in diet of the messes. We have all, of necessity, been on sea stores, without any variation, except the clams.

Careful examination of all cooking utensils used in preparing the clams for the messes showed them to be of "granite," except a cast-iron skillet. No vessel was used in any way which had a copper bottom. The clams were carefully cleaned and

were cooked within twelve hours after they were taken from the beach. The toxic principle exerted its greatest effect upon the nervous system.

The following symptoms were observed and may be thus classified:

I. **Gastro-intestinal:**
- (*a*) Cramps;
- (*b*) Anorexia;
- (*c*) Nausea;
- (*d*) Vomiting;
- (*e*) Tingling of oral mucous membrane;
- (*f*) Perverted taste;
- (*g*) Swelled tongue;
- (*h*) Diarrhœa; and
- (*i*) Sense of mobility and decadence of the teeth.

(*a*) The *cramps* were not severe, but were an almost constant symptom. They were chiefly abdominal, only one patient complaining of slight cramping in the extremities.

(*b*) *Anorexia* was a constant symptom.

(*c*) *Nausea* was also a constant symptom, varying in intensity from "squeamish" feeling or "goneness" to

(*d*) *Vomiting*, which was prevalent in 20 per cent. of the cases.

(*e*) *Tingling of the oral mucous membrane* was present in every case, but *not* anæsthesia.

(*f*) *Perverted taste* was complained of by most of the patients.

(*g*) Four patients complained of *swollen tongue* with tenderness. Inspection showed no perceptible œdema, and this symptom is believed to be one of several nervous disturbances of sensation observed.

(*h*) *Diarrhœa* was observed in only three cases, and in these cases, diarrhœal symptoms were not severe.

(*i*) *Sense of mobility and decadence of the teeth* was often complained of. The feeling was described as: "My teeth feel like they are loose and are about to fall out. I know they are not, but they feel that way." In every case the teeth were firm, there was no pain upon tapping upon them gently, and at this writing no other symptom has appeared. No signs of inflammation could be found in any case.

II. **Nervous Symptoms:**
- (*a*) Motor:
- (*b*) Sensory.

(*a*) The *motor symptoms* were as follows:
1. Muscular incoördination;
2. Muscular weakness;
3. Paralysis.

1. The *muscular incoördination* was observed in four cases, the patients having a staggering gait. This seemed to be due in part to weakness of the crural extensors. The foot was lifted higher from the deck than normal.
2. *Muscular weakness* was present in varying degrees of intensity. In

several cases the patients were unable to exert force to a painful extent by clasping my unresisting palm with all their might. "Weak knees" were observed, and a constant tendency of the head to fall forward was complained of.

3. *Paralysis* is mentioned as an extreme degree of depression which may occur when a toxic dose of the poison is taken. Both cats above mentioned showed motor, but not sensory paralysis of the hind quarters, and in attempting to walk the hind legs were dragged along as inert masses, just as if the vertebral column were fractured and the resulting compression of the spinal cord was producing paresis. One man had a dragging gait and the action of his facial muscles simulated that of a person whose face has been benumbed by prolonged exposure to a cold wind.

(*b*) *Sensory symptoms* of peculiar and diverse character were observed and were as follows:

1. Numbness;
2. Perversion of taste;
3. Loss of distance perception;
4. Vertigo;
5. Sense of walking up hill upon walking;
6. Myalgic pains;
7. Disturbance of tactile perception; and
8. Absence of anæsthesia.

1. *Numbness* was complained of in every case. The toxic principle seemed to evince selective action upon the sensory fibers of the fifth cranial, or the trifacial nerve. In every case the patient complained of numbness and tingling of the areas corresponding to the peripheral distribution of this nerve. In some cases the numbness extended to the extremities, and in these cases the involvement of the fifth cranial nerve seemed to be exaggerated. In the milder cases the fifth nerve alone was involved.
2. *Perversion of taste* was present. This was most probably due to the above-mentioned numbness.
3. *Loss of distance perception* was an interesting phenomenon observed only in one case. The patient was a strong man with no apparent predisposition to nervous temperament, or disorder. According to the patient's statement which is accepted, the patient's perception of distance was almost wholly lost. All objects seemed to be nearer to the patient than they actually were. He would extend his hand to take up an object, only to realize that the object was not within his reach. This condition compelled the patient to grope about as though he were blind. Yet he could see every object. In descending a ladder this phenomenon was particularly noticeable.
4. *Vertigo* was present in varying degrees in all cases. In no case was subjective vertigo observed, the symptom being of the objective type.

5. *Sense of walking up hill* was noticed in several cases. The patients, walking upon the level deck, felt as if they were walking up an ascent or sloping floor. This sensation caused the walking patient to lift his advancing foot from the deck to an unusual height.
6. *Myalgic pains* were present in four cases. The patients said their muscles were sore, as if they had been beaten. One patient compared the myalgia to that experienced at the onset of influenza.
7. *Disturbance of the tactile perception* was observed in most of the cases. I believe this to be due to the numbness. Tactile sensibility was very much obtunded.
8. *Absence of local anæsthesia* was present in every case. Pain could always be elicited with a needle point.

III. **Heart and vascular system** showed no changes of consequence. In the cases presenting marked nervous symptoms I fancied that I could detect slight acceleration of the heart's action and a correspondingly slight depression in the arterial system. Apparatus for the detection of this condition was not available and for clinical purposes we may say there was slight depression, if any at all.

IV. The **lungs** seemed to be unaffected. In fact, the effect of the toxic principle upon the thermo-cardio-respiratory tripod may be said to be negligible.

V. The **temperature** was unmodified so far as could be observed. Several patients complained of warmth, but there was an invariable absence of pyrexia.

VI. The **skin** was apparently in a normal condition so far as its functions are concerned. Careful search failed to discover any erythema or eruption of any description. One patient complained of formication. Pallor of the face was observed in about half the cases. Diaphoresis and pruritus were present in no case. Tingling, numbness, absence of local anæsthesia and obtunding of tactile sensibility have been commented upon in describing the nervous phenomena.

VII. The **genito-urinary system** presented no symptoms.

VIII. **Audition** was in no way affected.

IX. Except as noted under nervous symptoms **vision** was unmodified. Pupillary symptoms were entirely absent. A perhaps noteworthy symptom was the absence of anxiety or feeling of personal insecurity. No patient seemed mentally depressed; on the contrary, the patients whose nervous systems showed most marked symptoms were cheerful, one patient jokingly remarking: "This is a capital way to get a cheap jag." I regret that, owing to lack of facilities, I was unable to test the nervous and muscular reactions to electrical stimuli. From observation of these cases I failed to note a difference in severity of the symptoms following the ingestion of raw clams from those following the eating of cooked clams.

Cephalalgia, chiefly occipital, was a constant symptom.

The two cats were affected more profoundly. Vomiting, cramping, convulsions, etc., showed serious gastro-intestinal involvement. The effect of the toxic principle upon their nervous system was profound. Staggering, weakness, and motor paralysis of the hind quarters were observed. Cardiac

depression was present, but no other symptoms were observed. It is interesting to note that these animals ate with avidity any green vegetable matter offered to them. This may have been due to thirst on their part.

Conclusions:

I. That cramps, anorexia, nausea, tingling of oral mucous membrane, weakness, numbness, obtunding of tactile perception, vertigo and cephalalgia (chiefly occipital) were constant symptoms.

II. That the toxic principle exercised its influence chiefly upon the nervous system.

III. That the sensory nervous system was most affected.

IV. That the toxic principle seemed to possess a selective action upon the sensory fibers of the fifth cranial nerve, said action being constantly present and varying in intensity directly with the impression of the poison upon the general nervous system.

V. That the motor nervous system suffered, but less constantly, and to a lesser degree than the sensory.

VI. That symptoms of gastro-intestinal irritation were present in varying degrees of intensity, apparently bearing no definite relation to the severity of the nervous symptoms.

VII. That the thermo-cardio-respiratory relation was undisturbed.

VIII. That no effect upon the genito-urinary system was observed.

IX. That about 25 per cent. of the persons who ate clams were affected.

X. That persons who ate raw clams solely and those who ate cooked clams solely were affected alike.

XI. That analysis of the drinking water on this vessel fails to account for existing symptoms in those affected.

XII. That the food supply of the three messes differs in no way from what it has been for some days, except as to the addition of the clams as an article of diet.

XIII. That members of three messes having different food supplies and different cooking facilities, were affected similarly. The severer cases were treated with full doses of strychnine (sulphate) with excellent results. In the cases presenting mild symptoms nothing was done, except to watch them carefully and be on the *qui vive* for the development of graver symptoms.

These very interesting cases all terminated favorably, even the cats recovering, despite the severity of their symptoms. The above notes have been carefully made in the hope that they may prove of value.

Facilities were not available for bacteriological examination of these clams, and it is not known whether chemical or bacteriological poisoning was the cause.

CHAPTER XII

PRACTICAL INSPECTION OF FOOD

Inspection of food is one of the medical officer's most important duties. The following hints are given to the inspecting medical officer, as they have been found of value. Chemical analyses are omitted.

Bread.—Bread should be delivered in covered containers to protect it from dust, moisture and insects. The individual loaves should be wrapped. Contracts for bread do not always include wrapping of the individual loaf. Consequently there is a greater reason for insisting upon delivery in covered containers. Unless the medical officer is vigilant the bread will be delivered lying loose on the bottom of a dirty wagon bed and carried on board ship by sweaty arms in dirty clothing. The loaves should be nicely browned, should not be scorched and they should be carefully inspected for dirt or for the charred remains of previous bakings which will be found baked into the bottoms of the loaves.

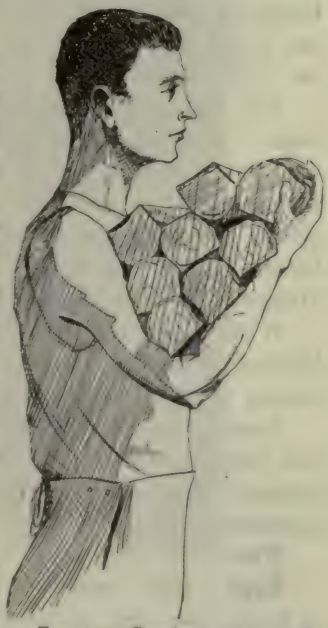


FIG. 31—Careless mess cooks carry loaves of bread on bare sweaty arms.

The examiner may gain information as to the character of the cooking by compressing the loaf gently between the hands. It should be resilient and not soggy. Soggy bread should be rejected at once (*a*) because it is indigestible, and (*b*) because it is an inferior article which weighs more than good bread. The bread should be sweet to taste and a portion of it taken and rolled between the fingers should be rolled into a hard ball with difficulty unless the loaf is slack baked.

The color of the interior of the loaf should be normal and there should be an absence of extraneous matter of all kinds; for instance, roaches, weevil, rat fæces. When sliced, the bread should show the normal cellular structure characteristic of good baking.

Meat.—The inspection of meat requires experience and should be carefully studied by the medical officer who has the interest of the men at heart.

When frozen meat is being delivered the same number of hind and fore quarters should be delivered unless the contract specifies differently. The meat should not be too light, nor yet too dark in color, and it should be remembered that the normal color of beef, pork and mutton is very different. If the meat is too dark in color ante-mortem disease may be suspected. The contracts no longer call for veal. Excess of bone should not be accepted and the examiner also should not accept meat where the trimmings will amount to more than 25 per cent. of available meat.

The surface of the meat should be barely moist to the examining finger. There should be no weeping from a greenish-grey, foul-smelling surface. The meat should not separate from the bone readily and a skewer thrust in near the bone, especially in the pelvic region, will almost always reveal a foul odor in decomposing meat. The pleura should be free of adhesions. There should be no evidence of disease. Stripped pleura suggests tuberculosis.

If the beef is frozen it should be delivered in burlap and should be handled in a cleanly manner, being put into the refrigerator without having opportunity to thaw.

Fowls should be examined at random for extra weight. Lead or iron slugs have been put into the cavities of dressed fowls in order to increase their weight. The odor and color are good guides to the examiner.

Fish.—See page 154.

Eggs.—Eggs should be fresh and clean. When a load of them is being examined samples should be taken from several cases and broken into a bowl to determine their freshness. The medical officer scarcely will have experience or apparatus for candling; however, the old egg, because of evaporation of its content, will give a sense of rattling within the shell when shaken close to the ear. The contents of the shell will make a noise indicating that the shell is not full.

Eggs which are wet or soiled should not be accepted. They may

be infected. The shells are porous. One has only to drop an egg into a solution of methylene blue and allow it to remain for a brief time to see how easily bacteria in solution may gain entrance to the interior of the egg. Decomposing eggs will float in water. Good eggs sink.

FIG. 32.—Mechanical potato peeler.

Green Vegetables.—Decomposing green vegetables and fruits should not be accepted as they are unwholesome and cannot be preserved.

Potatoes.—The examiner should make due allowance for a small percentage of mechanical injuries and for small potatoes. The writer has found almost a bushel of small potatoes and dirt in a barrel of potatoes which a dealer was trying to deliver. Potatoes less than

2 inches in diameter should not be accepted. They cannot be peeled readily by hand nor can they be well pared by the mechanical potato peeler. Potatoes which show a large percentage of decay or attack by worms should be rejected. Large potatoes should be cut in halves at random as they frequently are diseased and have large cavities on the interior surrounded by a dark area. Potatoes should be clean. Dirt is heavy. It makes weight. Potatoes are sold by the pound.

Sweet Potatoes or Yams.—Sweet potatoes or yams should be of size sufficiently large to be pared properly by hand and should not consist of nodular, irregular long tubers of small diameter which sometimes are delivered. The flesh of the sweet potato should be almost white to yellow, depending upon the variety, and show none of the black mottling characteristic of the potato which has been frosted.

Turnips, carrots, salsify, parsnips and onions should be delivered clean, free of their tops, and should not show the wrinkled appearance characteristic of those vegetables when they have been long out of the ground and have dried out. The examiner should not insist upon beets being delivered washed as they do not keep well after being washed. The tops should be cut off before delivery.

The stems of **rhubarb** should be delivered free from the leaves. **Water cress** should not be accepted on board as a salad. Its source is too questionable.

Cabbage and Celery.—Cabbage and celery should be of good quality and fresh. The examiner should reject celery, cabbage and lettuce which is badly blackened by mechanical injury, provided such blackened portions constitute a considerable percentage of the weight of the delivery.

Fruit—Citrous Fruit.—Oranges, grapefruit and lemons should show a clear, rounded, succulent oily skin which should not be too thick. It should not be wrinkled and hard. This indicates that the fruit is old. The individual pieces should be heavy. The light orange or grapefruit is of poor quality and usually dried out, yielding little juice.

Apples.—Sour apples should not be accepted if it can be avoided. They will not be eaten and require too much sugar in their cooking. They should be fresh, clean and not dried out, as will be indicated by wrinkling of the skin. Imperfect apples should not be accepted.

Cheese.—Cheese should be of good quality, wholesome in appearance, and delivered in closed containers. Canned cheese is delivered

from time to time which has undergone butyric acid fermentation on its exterior. It is very foul smelling, mushy, and appears to be unwholesome, but if this exterior layer be removed wholesome cheese will be uncovered. If the cheese is black on the outside, and particularly if there is roughness of the interior of the can, indicating that the metal has been attacked, the cheese is unfit for consumption.

Butter.—Butter is usually delivered in tubs and should be of good color, not rancid, and fresh to smell and taste. At times butter is worked over by the dealers and contains a large amount of water. This of course adds to weight, butter being sold by the pound. This water is contained in cavities in the butter which may not be apparent from the surface. It is easy to make the surface appear homogenous by the local application of heat.

The only way that a tub of butter can be examined in the hurried inspection which is practicable is by the aid of a trier. The long cylinder of butter removed by this instrument will cut through the cavities and excess of water will be immediately apparent. Further, the cylinder of butter may be examined as to color and quality. Rancid butter at the bottom of the tub thus may be detected, even when covered by fresh butter.

FIG. 33.—The butter trier; an invaluable aid in inspecting tubs of butter.

Milk.—The practical inspection of milk upon delivery is almost wholly limited to seeing that the milk comes from approved contractors whose establishments are known to be properly controlled by the health authorities and that it is delivered in a clean manner and surrounded by ice.

The bacteriological examination requires time as does the cell count. These are impracticable as they create delay to the delivery wagon. The examination as to the method of delivery and the taking of the specific gravity are as much as can be done. All milk brought on board ship should be pasteurized or boiled.

Biscuit.—When packages of biscuit are brought on board the parcels should be selected at random and opened to be examined for weevil.

The Bum Boat.—While the bum boat is prohibited by regulation in the fleet, when ships are at navy yards, certain small dealers in food stuffs, principally confectionery and milk, have permits to sell within the limits of the naval station and frequently station themselves and their wares at the brow on the dock.

Unless these small dealers are kept under close supervision they may be very filthy in their handling of foods and may spread disease. The boxes in which their wares are contained have been found extremely filthy. The pies and cakes often are left exposed on boards to be soiled

FIG. 34.—Bum boats—small boats in which petty dealers bring their wares alongside for sale.

by insects and the clouds of dust that often are blown down the dock. Milk is allowed to stand in bottles in the sun, and the average of these dealers appears to have little interest other than the collection of the money for poorly handled or dirty food. The medical officer should have these wares inspected or should inspect them personally himself daily before permission is given for men to buy. If the confectionery is handled in a dirty manner, is not properly covered or of poor quality the medical officer should unhesitatingly deny the privilege to sell to the ship. After one or two rejections of this character the dealers usually will handle the food properly. The medical officer should assure himself that milk is delivered properly iced, and that the dates

on the caps of the bottles show that the milk has been bottled within twenty-four hours. Often the bottles will have a collection of water and dirt on top of the paste-board cap. The dealers should be cautioned to ice the milk in such a way that this cap will not be fouled and that polluted water may not enter the bottle when the cap is withdrawn.

CHAPTER XIII

CLOTHING

Clothing is material used by man to protect his skin from trauma, heat, or cold, and to adorn or conceal his person.

These materials are derived from the Animal and Vegetable Kingdoms:

From the Animal Kingdom:

Silk;
Wool;
Leather;
Fur.

From the Vegetable Kingdom:

Cotton;
Linen;
Other fibers and papers.

The above are the common sources for man's clothing of animal and vegetable origin, but by no means embrace all sources from which man obtains his artificial covering.

From the Animal Kingdom

Silk is made from the fibers of the cocoon of *Bombyx mori* and other kinds of bombyx or silk spinners. The fibers are cylindrical, smooth, and under the microscope present neither joints nor imbrications. They are yellow in color in the raw state.

Wool fiber is obtained from the hair of many animals, sheep, goats, alpaca, camel, etc.

Under the microscope the wool fiber presents characteristic imbrications, the scales of the hair overlapping each other like the shingles on a roof, giving the wool fiber an unmistakable appearance. This fiber is considerably larger than the silk fiber.

Leather is the skin of animals appropriately treated or dressed.
Fur is the skin of fur-bearing animals.

From the Vegetable Kingdom

Numerous plant fibers are used in various parts of the world. We shall concern ourselves with cotton and linen.

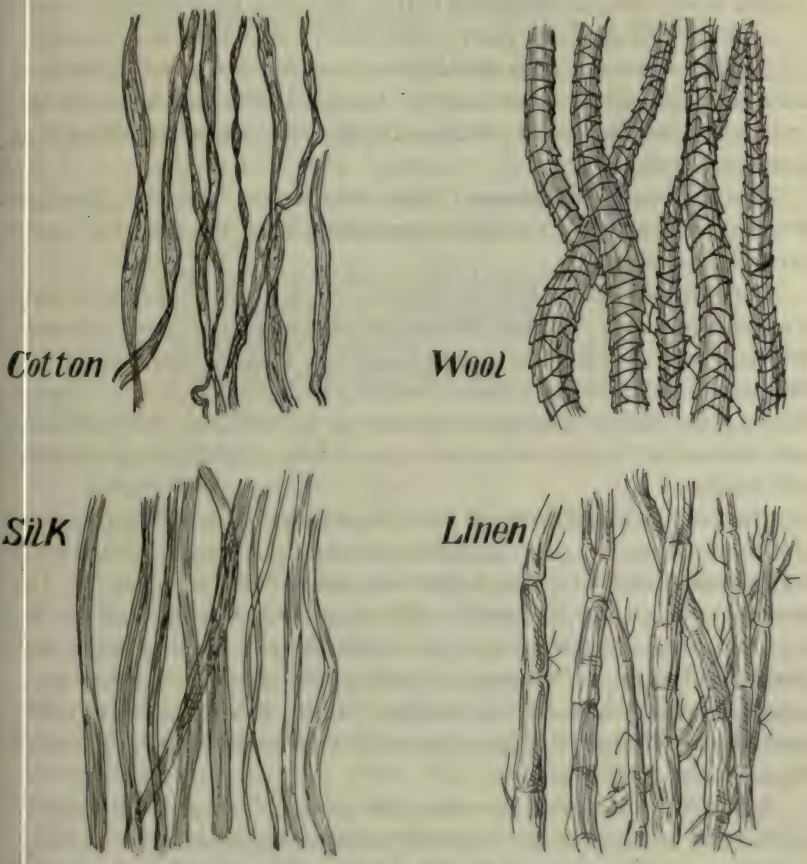


Fig. 35.—Fibers of cotton, wool, silk and linen drawn from microscope preparations.

Cotton.—This is the seed hair from the cotton plant, and is ordinarily 15 to 20 microns thick. The fibers are spirally twisted on their long axis as viewed under the microscope, and present a reniform or flat transverse section. The surface of the fiber is rough.

Linen comes from flax and in its prepared state is a somewhat round fiber 12 to 26 microns long and showing transverse and longitudinal fissures. Usually there is little difficulty in identifying these fibers under the microscope, but when a microscope is not available the following simple tests may be made:

1. *Burning.*—Wool and silk give off an empyreumatic odor like burned horn, whereas linen and cotton give odor as of burning paper.

2. *Wool and silk burn poorly* while linen and cotton burn readily.

3. *Wool* is very *slightly soluble in* 10 *per cent. hot potassium hydrate solution,* while *silk dissolves readily.* Cotton and linen are unaffected.

4. *Cold sulphuric acid readily dissolves silk, cotton and linen,* but slowly dissolves wool.

Any of the above-mentioned fibers when woven into cloth, or when mixtures of the above are woven into cloth, form the fabric of which garments are made.

Clothing affords protection against cold by means of imprisoning a warm layer of air, which is the poorest of conductors of heat, between the body and the garments; consequently a loose garment is warmer than one of the same material and weight which fits tightly, *e.g.*, Chinese clothing, and also several layers of clothing, by virtue of their subjacent and confined air layers, are warmer than one layer of the same material and weight.

The average temperature of our climate is far below the specific heat of man, consequently the organism must maintain combustion processes for liberation of heat. The higher the amount of heat given off, the more must the body be heated—this means the greater must be the ingestion of food materials and protection of the body with additional clothing. Hence the wearing of clothing has an actual bearing upon required amount of food, the necessity under given conditions being greater or less, depending upon the extent to which clothing prevents the escape of body heat.

Again clothing renders more easy the giving off of heat from the body if, as result of physical exercise or of excessive ingestion of foods, much heat is generated, and especially if in addition the atmospheric temperature of our warm season renders more difficult the cooling of the body.

Body heat is lost through:

(*a*) Radiation;
(*b*) Conduction;
(*c*) Evaporation.

(*a*) **Radiation.**—At room temperature of 15°C., if the *radiation* from the nude skin be placed at 100 per cent.,

Clothing with wool shirt allows a radiation = 73 per cent.
Clothing with linen shirt and wool shirt allows a radiation..... = 60 per cent.
Clothing with wool shirt, linen shirt, vest and coat allows a radiation..... = 33 per cent.

A fully dressed man loses through radiation only one-third of the heat he would give off if his body were nude.

(*b*) **Conduction.**—Originally it was believed that the heat conduction of a given material was dependent upon thickness of material employed. Rubner's researches have shown that various clothing materials possess very different powers of heat conduction.

Placing conduction of air at unity = 1
The conduction of hair of animals = 9
The conduction of silk = 16. 7
The conduction of plant fibers = 16. 7

The above figures refer to the dry material. When wet, these materials act differently, and

(*c*) **Evaporation** comes into play.

Clothing materials capable of water absorption hold water either from the body or without in two ways:

1. By actual *hygroscopicity*, in which the basic fibers absorb water and swell, tending to reduce the size of mesh in the cloth. Animal fiber possesses this to greater degree than plant fiber.

2. By *water of interposition*, which is not absorbed by the fibers, but merely lies around them in minute drops, and occludes the air spaces or meshes between the fibers. The quantity of water of interposition is more dependent upon the weave than upon the fiber, and can be wrung or pressed out. Not so with *water of hygroscopicity*.

Man finds that material most comfortable which absorbs water with difficulty and gives it off slowly. It is highly desirable that the material shall not lose greatly its essential elasticity, but shall stand out from the body surface, allowing an air layer to be interposed, rather than that the moist fabric shall lie wet upon the body surface. Air conducts heat only one twenty-eighth so rapidly as water. Close approximation to body surface prevents proper evaporation from skin

and proper excretion of carbon dioxide from skin surface, causing loss of heat in winter and retention of heat (prevents evaporation) in summer.

This produces discomfort by reason of improper hindrance of radiation, as is experienced when wearing rubber coats or other air-tight garments.

Wool appears to be the only fabric which when saturated still permits passage of air through its substance and should be loosely woven. Many cannot wear wool next to the skin because of disagreeable sense of irritation of the surface. It tends to absorb odors. Again, wool shrinks if carelessly washed in hot water, is relatively expensive, and is more quickly worn out.

Despite the above-enumerated objections, wool is most desirable, because it best corresponds to the requirements of hygiene.

As between linen and cotton fabrics linen is smoother, brighter, stronger, more durable, irritates the skin less, and by virtue of the smoothness of its fibers retains dust and bacteria upon its surfaces to less degree than cotton. For underwear linen is smoother, cleaner, cooler, permits more ready evaporation of perspiration, and absorbs perspiration more readily. Hence gives more general comfort to the wearer.

The color of clothing exercises a very marked influence upon heat absorption, white being least, and black or dark blue most absorptive.

Coullier found that a thin cotton cloth laid over dark woolen cloth in sunshine reduced the temperature of the woolen cloth 12.6°F.

Since white absorbs less heat than any color it is most generally worn in hot climates. Despite this quality, its conspicuousness and the difficulty of keeping it clean render it unsuitable for use for the navy afloat or ashore, yet it is the prescribed color for summer uniform.

For military reasons it is desirable to have the uniform of a body of men as inconspicuous as possible, so that they may not be recognized in the distance because of color of clothing, and also because it is undesirable to offer a good target to the enemy.

In the day white is most conspicuous in the distance, dark blue and scarlet next. Least easily recognized in average circumstances is perhaps "khaki," which is used by our troops (Army and Marines), in summer or warm weather. The olive drab uniforms worn by the Army are equally protective. Mosquitoes are not attracted by khaki color.

If clothing is to be used to protect against heat, then we should choose the colors which reflect a maximum of heat rays and absorb a minimum. If we place the absorption of heat rays by white fabric at 100, then

Khaki	= 102
Dark yellow	= 140
Light green	= 155
Dark green	= 169
Bright red	= 165
Light blue	= 199
Black	= 208

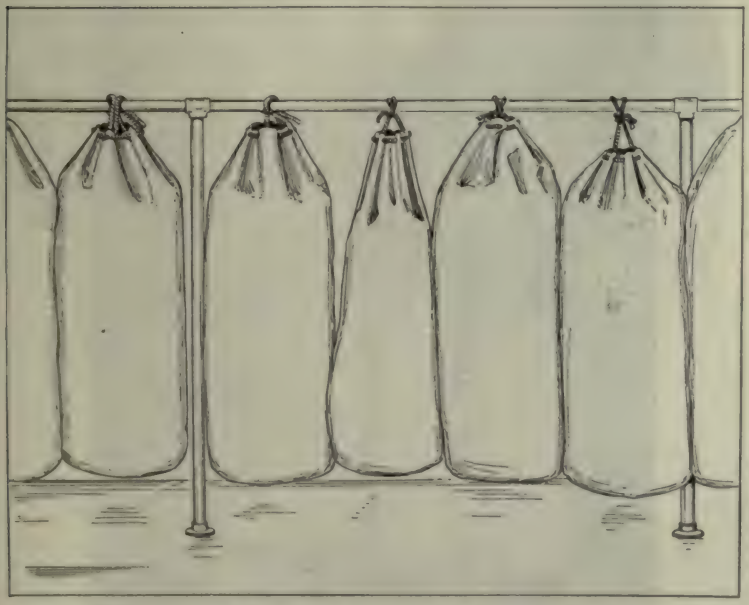


FIG. 36.—Canvas bags of clothing belonging to enlisted men. These are their trunks. They make an excellent container for their clothing.

ARTICLES OF CLOTHING

The clothing of the enlisted personnel in the lower ratings is rolled, stopped, and neatly stowed in canvas bags. These bags are lashed to an iron rail or "bag netting."

The **underclothing** of the Navy consists of light nainsook short-

sleeved undershirts and running drawers for warm weather. Light-weight cotton shirts and long drawers also are provided for summer wear.

In winter heavy woolen underwear is provided. This fabric contains an admixture of cotton. The underwear is in two-piece suits: shirt and drawers.

FIG. 37.—Short-sleeved undershirts worn in warm weather.

For **outer clothing** in **warm weather** the officers' uniforms are made from cotton or linen duck. Those of the enlisted men are made of cotton drill. These are two-piece suits, and consist of blouse or "jumper" and trousers.

FIG. 38.—Blue blouse service uniform worn by commissioned and warrant officers. (*Uniform Regulations.*)

FIG. 39.—White service uniform worn by commissioned and warrant officers in warm weather. (*Uniform Regulations.*)

In **cold weather** navy blue cloth or serge is used for **outer clothing,** the cut of the clothing depending upon whether it is intended for enlisted men, chief petty officers, or officers of the warrant and commissioned grades.

The **blouse worn by the commissioned and warrant officers,** whether made of cloth or white duck, fastens closely at the neck and has high standing collar. While this feature is desirable in winter, in summer the collar about the neck is uncomfortable. This blouse permits less freedom of action than the double-breasted reefer coat worn in other navies.

When well made the blouse of the American naval officer is distinctive and its disadvantages are so few that its continued use is desirable. The **coat worn by the chief petty officers** is a double-breasted reefer coat made of cloth, serge, white duck, or drilling, as may be indicated. This wide open, "V"-shaped collar necessitates the wearing of shirts, stiff collars, and ties. In summer it is difficult for chief petty officers to carry a supply of linen sufficiently great to appear neat at all times. A tunic fastening at the neck would permit the wearer to lay aside collar, tie, and shirt, with corresponding increase in comfort, convenience, and improvement in appearance.

The **outer clothing of enlisted men** below the grade of chief petty officer consists in **jumper and trousers** made of white drilling. These are loose and permit a maximum of freedom of action. Since the white jumper falls loosely over the trousers at the waist band and is open at the neck and sleeves, free circulation of air is facilitated. The white color and the free circulation of air under the jumper make it a comfortable garment for wear in warm weather.

While white clothing has many advantages it possesses the disadvantages of being too conspicuous and easily soiled, especially ashore.

At Vera Cruz abundant opportunity was afforded to see the pitiable unsuitability of white uniforms for service ashore. To render themselves less conspicuous to the bullets of snipers, improvised dyes, drenching with coffee, and actual wallowing in mud were resorted to by men who realized the danger to which a white uniform exposed them.

Khaki, olive-drab or slate-colored, easily washable cotton uniform, would prove more serviceable and more nearly meet all the requirements of tropical service for both officers and enlisted personnel.

FIG. 40.—Blue service uniform worn by chief petty officers (on the left). On the right is a bluejacket in service blue. (*Uniform Regulations.*)

FIG. 41.—White uniform of enlisted men. A chief petty officer on the right. (*Uniform Regulations.*)

For **working parties** and in the engine room **blue dungarees** are used.

In **cold weather** the **enlisted personnel** below the grade of chief petty officer **wear a suit** made **of navy blue cloth or serge** and cut after the pattern so commonly know as a "sailor suit." This consists of a **loose blouse** having a wide sailor collar and sleeves having wrist bands which button tightly at the wrist, thus confining some of the warm air heated by the body. The large opening at the neck, however, permits the escape of the air, and unless very heavy undershirts and sweaters are worn, the sailor's blouse is apt to be a very cool garment. It is loose and permits utmost freedom of action for the wearer. The **trousers** are cut after the pattern of the old-fashioned barn-door trousers which were discarded generations ago in the general interest of efficiency. The legs of the trousers are very loose and have a marked swell at the bottom, enabling them to be rolled up easily when necessary for wading. These trousers have a lacing at the back of the waist and fit very snugly, being worn without suspenders. The writer is of opinion that this feature is a considerable factor in the production of the hernias which are so much seen in the service.

The **pea coat** used by the enlisted men is a short, double-breasted reefer coat buttoning closely at the throat, is made of heavy dark blue cloth, and while reasonably warm affords little protection to the lower extremities. Its collar is wide and when turned up gives protection to the neck.

The **overcoat** worn by commissioned and warrant grades is a long, double-breasted coat made of heavy pilot cloth which extends well below the knees and fastens closely at the throat. It has a slit over the left hip to permit the wearing of the sword.

For officers a long, heavy cloth cape or **"boat cloak"** is provided. This cape falls below the knees and is a very serviceable garment, especially for wear in boats, as in the case of accident the wearer may release himself from it quickly and commence swimming. The heavy overcoat could not be readily discarded by the wearer in the water.

Head-gear.—Commissioned, warrant, and chief petty officers wear cloth caps with visors projecting over the eyes at an angle of about 40 degrees. The visors are of dark leather and offer some protection to the eyes in bright sunlight. These caps afford no protection to the back of the neck in falling weather or under a hot sun.

FIG. 42.—Bluejacket and chief petty officer in pea coat and overcoat respectively. (*Uniform Regulations.*)

FIG. 43.—Overcoat and boat cloak worn by commissioned officers. (*Uniform Regulations.*)

For wear in hot weather a cap of similar shape, having a removable white duck or drilling cover, is substituted for the cloth cap.

A cork or pith helmet with visor extending well backward over the neck is desirable for those who must stand watch under a tropical sun.

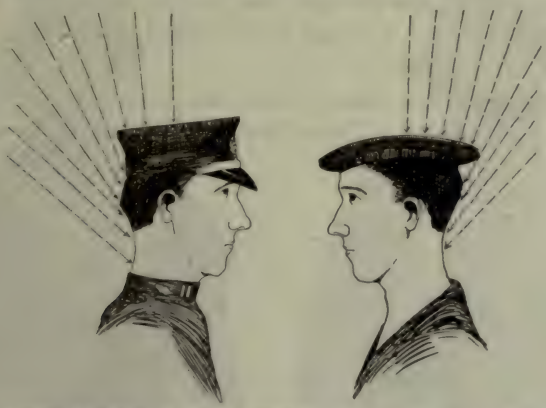


FIG. 44.—Unless the sun's rays fall vertically, or nearly so, the back of the the neck receives almost no protection.

The bluejackets wear a flat sailor hat made of cloth. A removable steel grommet is worn within the cap and serves to produce the disk-shaped cap, known as a sailor's cap. In windy weather the flat cap is easily blown off; consequently the grommet is often removed and the hat is converted into an inverted bag on the sailor's head.

The flat hat is peculiarly ill adapted for its purpose. It affords little protection to the wearer from sun or rain and blows off easily. A "watch cap" of knitted blue yarn is much worn by the men on deck in cold or windy weather.

FIG. 45.—Unshaded area indicates unprotected surface where vital centers are most superficial.

The white hat worn by the bluejacket is made of several thicknesses of white drilling stitched together, forming a skull cap to which is attached a brim of the same material, heavier, and stiffened by close stitching. This brim when turned down over the eyes affords a little protection, and if the brim be turned down at the back, considerably more protection is given than by the flat hat above mentioned.

The writer thinks that if the brim of this hat were widened posteriorly, giving it somewhat the shape of a "southwester," that it would afford much more protection.

Green leaves or a wet handkerchief should be worn under this white hat in a hot sun, or else the hat itself should be wet. A hat shaped like the "southwester" and wet would afford considerable protection to the back of the neck.

Rain Clothes.—For officers and men standing watch, oil skins are used as rain clothes. These consist of a thoroughly oiled water-

FIG. 46.—The white service hat now in use (brim turned down). On the right is a sketch of a cloth hat suggested by the author. The brim should be stiffened by stitching.

proof coat, buttoning closely at the neck, and water-proof trousers of the same material which come down over the tops of rubber boots. Sometimes long oil-skin coats are worn without trousers. These coats come down below the tops of the boots. "Southwesters" are worn by officers and men as head-gear in falling weather.

A black **mackintosh coat** with cape attached is prescribed for all commissioned officers for wear in rainy weather, and a cap cover made of oil cloth is worn.

Foot-gear.—In wet weather rubber boots and rubber hip boots are worn.

In summer with white uniforms white canvas shoes are prescribed for the officers.

The enlisted men wear, summer and winter, high black leather shoes of the Blucher pattern having a cap at the toe, broad low heel,

FIG. 47.—Rain clothes of the enlisted men. As stated in the text, these are also worn by the commissioned officers frequently in preference to the mackintosh coat. (*Uniform Regulations.*)

FIG. 48.—A skiagram showing a foot deformed by wearing shoes too narrow at the toe. The great toe is bent toward the mid-line of the foot. The other toes are deformed, the outer three are also turned toward the mid-line and overlap each other. This deformed foot was X-rayed in a shoe having a pointed toe.

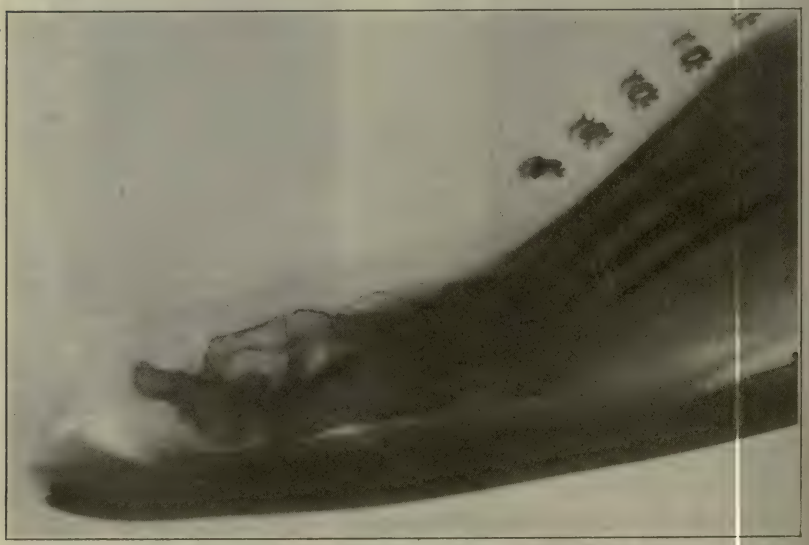


FIG. 49.—Skiagram of foot deformed by wearing shoes having pointed toes. The great toe is bent toward the mid-line of the foot. The second toe is a hammer toe. The other toes are deformed and overlap. (*X-rayed in the shoe.*)

thick soles and a wide toe to enable the spread of the foot. Shoes should be abundantly wide, for the foot spreads a half-inch in width when the individual rises and is carrying a weight equivalent to that of a bluejacket's accoutrements when he is in heavy marching order. The individual should be required to stand on one foot and sustain a weight of 40 pounds while being fitted. This produces maximum spread of the foot. As the average of enlisted men are vain about appearance of their feet they tend to select shoes too small for themselves. The company officers should be required to fit the men with shoes to insure that they are properly fitted.

Socks.—Socks are of cotton or wool and should be free of holes. They should not be so large as to enable the formation of creases which tend to produce blisters.

Extra Heavy Clothing

For service in the very cold climates the following clothing has been supplied to the naval service and may be worn either by officers or enlisted men:

Long, **heavy merino drawers** and extra heavy long-sleeved **undershirts** of the same material are provided. These undershirts are reinforced front and back by a second layer of the same material. The front and back pieces are sewed on to the shirt and form a double thickness from the neck to the waist. The neck band is made to fit snugly so as to retain the layer of warm air under the shirt.

The **socks** are made of extra heavy wool and afford splendid protection to the feet. They are intended to be worn over lighter cotton or woolen socks. The **boots** are high leather boots, having a sole at least ½ inch thick. The uppers are sewed to the leg of the boot by three rows of strong stitching, and a row of similar stitching binds the counter to the upper. These leather boots extend to the knee and are sufficiently large to contain the lower ends of the trouser legs.

For wet or snowy weather a high **arctic overshoe** or boot is provided. It is coated with rubber. The seams are well sewed and the boots are laced by means of eight eyelets on each side of the long tongue, which is fastened to the sides by water-proof seams and cement. The leg of this boot is large enough to include the lower ends of the trouser legs of the wearer. The tongue is reinforced at the bend of the ankle by a piece of rubber which is cemented on to the front of it. This boot is large enough to be worn over the shoes.

The hands are protected by heavy **mittens** made of blanket material ribbed at the wrists to protect them.

The blue trousers and jumper are worn with or without a pea-coat. Over this is worn an **overshirt** made of heavy woolen material, having a hood continuous with the neck. This overshirt has no buttons, but is slipped on and the opening at the neck is laced so that the hood covers the entire head except the face. This overshirt extends almost down to the knees.

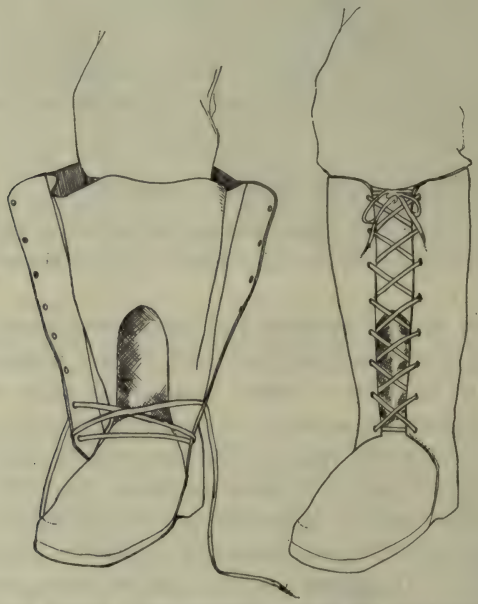


FIG. 50.—Heavy rubber arctic overshoe. Note the reinforcement in front at the bend of the ankle.

For wear in **wet weather a mackintosh suit** consisting of jumper and trousers is provided. The jumper slips on over the head, and the opening at the neck is closed by two flaps, the outer overlapping the inner and serving the double purpose of reinforcing the mackintosh layer over the chest and keeping water from being blown in through the seams. A puckering string around the margin of the hood enables it to be drawn tightly around the face and a puckering string at the lower margin of the jumper draws it tightly around the waist when tied. The wrists are supplied with snap catches so that the sleeves may be

doubled in to fit the wrists. For purposes of ventilation four eyelets are placed under each arm pit.

The trousers, made of the same material, are large and roomy, tapering at the ankle where they are fastened by catches which enable their close fitting to the ankle. The trousers are merely large garments which slip on without any buttons and which are fastened at the waist by a heavy puckering string which runs through the large seam at the waist band.

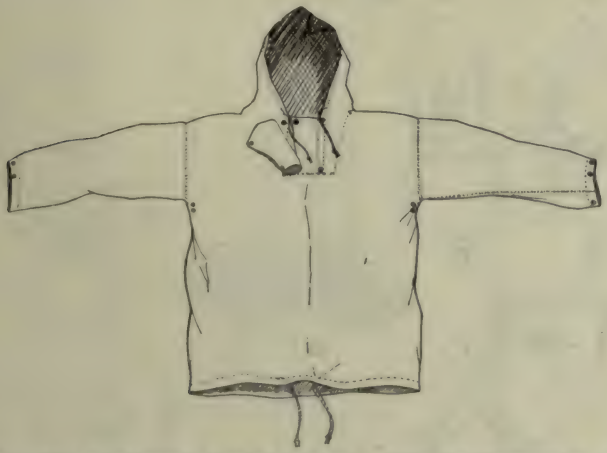


FIG. 51.—The mackintosh hooded jumper. Note the draw-string around the margin of the hood; also the protecting flap at the neck. This is an excellent garment for wear in cold, wet weather.

THE AVIATOR'S CLOTHING

To resist the chilling effect resulting from wind and altitude the aviator should be warmly clad. Likewise, in order to protect the head against injury the head guard should be of rigid character, light and warm. The necessity for quick action in the operation of the airplane's controls requires that the clothing be of such character as to hamper in no way the motions of the wrists and arms. At times these motions must be made with lightning speed and any hampering garment might be a factor in producing disastrous accident.

In the U. S. Navy **a helmet** made of **extra heavy sole leather** having ear cones and a wool fleece lining is worn. When in the machine the aviator is strapped to a small seat, works in a very small cockpit,

having only a few inches of elbow room. When the airplane dives, turns, or climbs at sharp angles the lurch suddenly may strike the head of the aviator against the edge of the fusilage, causing severe injuries to face and scalp.

The heavy sole leather helmet which fits well down over the head and is strapped under the chin with heavy sole leather ear pieces gives much protection. The openings of the ear cones are directed backward and protect the external auditory meatus from the blowing of the wind

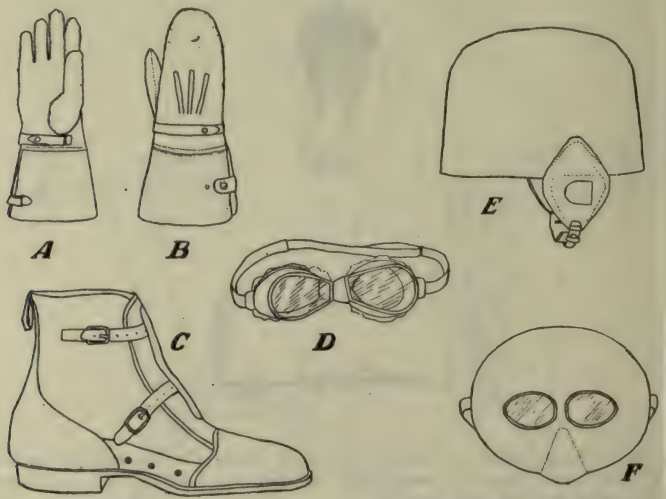


FIG. 52.—Aviator's clothing. *A* and *B* represent heavy black leather gauntlet and mitten respectively. *C* shows the heavy wading shoe; note the eyelets for escape of water. *D*, goggles made of non-splinterable glass. *E*, heavy sole leather helmet; note the ear protectors having openings directed backward. *F*, leather face mask having goggles of non-splinterable glass.

across the mouth of the canal and consequent interference with hearing. This helmet has prevented many severe injuries of scalp and face.

During severe weather a soft leather **face mask** with goggles made of *non-splinterable glass* affords protection to the face. In weather less severe a safety glass goggle made of non-splinterable glass is worn. These goggles may be strapped securely to the face and are so mounted that the eyes receive thorough protection from the wind.

The body is protected by a **two-piece suit of tan leather** sufficiently large to permit the retention of a layer of warm air of considerable thickness about the body of the aviator.

The *coat* has a heavy detachable lining and the garments are made of leather which has been specially treated to resist absorption of water. The *trousers* are tied at the bottom or else inserted into heavy fleece-lined leather boots.

The aviator in the naval service, especially at training stations, may have to work around his machine in shoal water. For this purpose "waders" or mackintosh cloth trousers having stocking feet are worn with brogans made of heavy leather and canvas. These brogans have heavy hobnails on the soles and heels and have eyelets on the

FIG. 53.—Aviator's clothing. *A*. Heavy two-piece leather suit. *B*, aviator fully clad in leather suit, helmet, puttees, etc. *C*, "waders."

sides allowing water to flow in and out. These heavy shoes are worn for the purpose of protecting the feet of the "waders" mentioned above.

The hands are protected by black leather gauntlets which are wool lined, also a wool-lined black leather mitten is used. These mittens and gauntlets commonly are worn over warm gloves. Electrically heated clothing is worn by aviators who now are fighting in the cold air at an altitude of 20,000 feet above the earth's surface.

CHAPTER XIV

PARTS OF THE SHIP AND HEALTH.

The Deck Watch.—The watch on deck is stood in periods of four hours each except that the period from 4 : 00 to 8 : 00 p.m. is "dogged" or divided into two watches of two hours each so as to give an uneven number of watches and so prevent the men from standing the same watch each day.

The duties of the watch officers and crew require that they lose a certain amount of rest at night. Also those who stand watch on deck are exposed to the weather conditions which prevail. In the summer and in the tropics awnings should be spread to protect against the sun, and in rainy and winter weather appropriate clothing must be worn for protection. Weather screens should be spread to protect against wind and weather. On the steel bridge linoleum or wooden gratings should be placed for the protection of the feet of watch standers both against the cold and heat. Also the wood gives resilience not possessed by steel and affords relief to the watch standers.

To protect the eyes against the glare in the sunlight or tropics amber or dark glasses should be worn. Those standing watch should have keen vision and hearing in order properly to interpret signals and avoid danger.

The nervous strain from standing watch in a fog or at night tends to break down those of unstable nervous system.

The irregular hours for sleep and the hurried meal taken by those going on watch, or the delayed meal taken alone by those coming off watch, operate to cause irregularity of digestive function.

During the morning hours when the deck is being scrubbed those on watch unless in rubber boots will get their shoes saturated with salt water and this consequent chilling tends to produce respiratory diseases, as well as tonsilitis and rheumatic affections.

Men on watch in the crow's nest should not be kept on duty longer than two hours in cold weather.

Search Lights.—Men operating search lights are exposed to the effects of the rays upon the eyes. These cause marked conjunctiviti

and severe retinitis with photophobia. Protective goggles should be worn.

Life Lines.—Around the decks of ships are situated the life lines which protect members of the crew from falling overboard during

FIG. 54.—During certain conditions the smoke and gases from the smoke pipe make the fighting tops almost uninhabitable. Smoke helmets are needed.

their activities in the day or at night. These lines are situated approximately at distances of 1, 2, and 3 feet above the deck. When

ships are cleared for action the lines are taken down. Men should not be allowed to sit on benches near them. The writer saw a case of drowning resulting from a man's lying on a bench at night, falling asleep, and rolling overboard between the life lines. (See Fig. 15.)

Fighting Tops.—During target practice and in time of action when range-finding parties occupy the fighting tops, discomfort may be extreme because of the smoke from the ship's smoke pipes. If the wind is in the right direction, the hot air and smoke as well as gases of combustion produce serious discomfort; also, cinders are apt to blow into the eyes and to cause injury by reason of the fact that they may be almost red hot when striking the eye or skin. The parties in the fighting tops also suffer from extremes of heat and cold, depending upon the weather. In summer the heat and glare of the sun produce sunburns and retinal hyperæsthesia. In winter the lofty position is exposed to the full sweep of cold winds and methods of heating cannot well be employed, although an electric heater is a possibility. The absence of cover leaves the occupants of the fighting top exposed to rain, sleet, and snow. And the surface upon which they stand, being of cold steel, readily conducts the heat from the feet and causes rapid chilling. Injury from falls received while climbing to or from the fighting tops is not uncommon.

The Engine Room.—The engine room is hotter than the fire room. That of a reciprocating engine is hotter than the engine room of a turbine engine. The wild heat from the pipes and engines, together with steam leaks, causes an extremely uncomfortable temperature at times.

The removal of wild heat should be accomplished through natural and artificial ventilation. In time of action, when battle hatches are down, the development of high temperatures becomes serious. Insulation (lagging) should be employed wherever possible to prevent escape of heat from pipes, boilers, evaporators, condensers, and so forth, thus limiting wild heat.

The engine-room force works under conditions somewhat similar to those of the fire-room force and tends also toward physical deterioration.

At times the ventilating system will supply fresh, cold air delivered directly upon the body of the overheated engineer who may be on the engine room platform. This predisposes to respiratory and

muscular affections. The man at the throttle should be keen and alert, as upon the quickness of his obedience to signals may depend the safety of the ship.

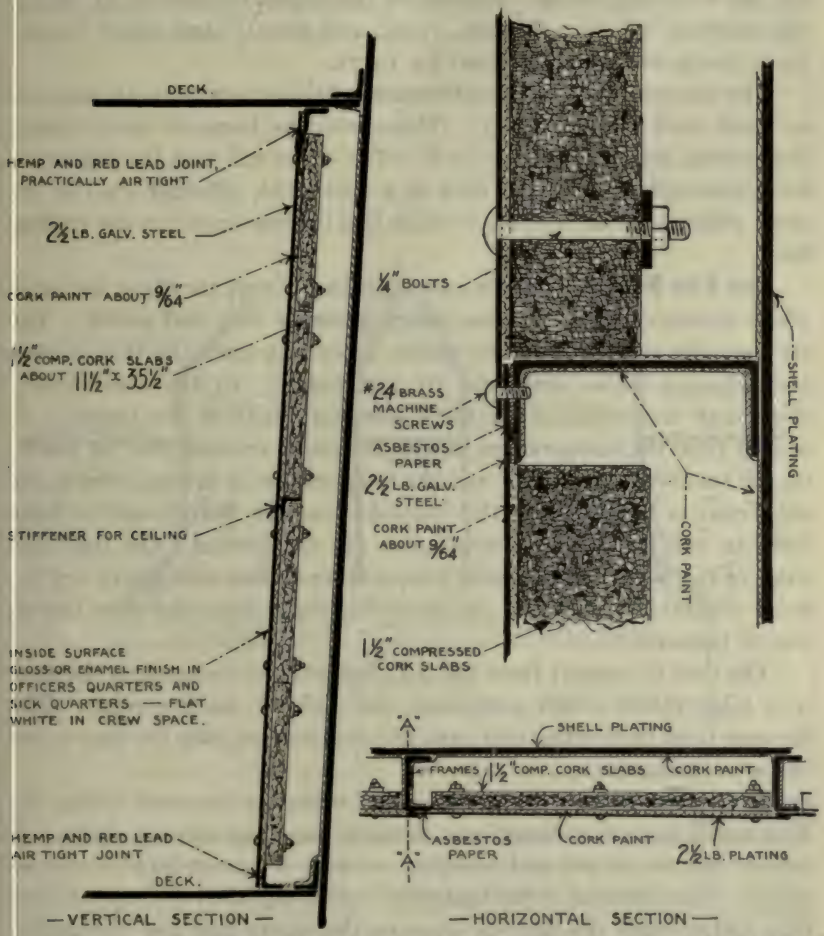


FIG. 55.—Cork slabs are bolted to bulkheads to limit the escape of wild heat. The slabs are shown in place. (*Gatewood.*)

The platforms, made of metal gratings upon which much of the engineer's watch is stood, should be insulated as far as possible to prevent the relaxing effect of heat upon the ligaments of the feet and the sweating which results from exposure to the high temperature.

As in the fire room, the problem of drinking water supply is unsatisfactorily settled.

The engine-room force shows a high admission rate per thousand for the following classes: diseases of the digestive system, 81 to 83; non-venereal infective diseases, 76.19; and wounds and other injuries 79.27 (Surgeon General's report for 1917).

The engine- and fire-room forces on coal-burning ships are exposed to much heat while on duty. This should be borne in mind during inspections, parades, etc., on deck. The writer has seen the engineer's force thoroughly chilled on deck in a cold wind, although clad in the same uniform as the deck force which had become inured to the chilling blast.

The Fire Room.—The fire rooms on board ship are those spaces in which firemen attend the fires which generate heat and power. The temperature in the fire rooms varies, depending upon the type of ship and whether oil or coal fires are maintained. In the coal-burning ships high temperatures are often seen, especially in the tropics. It is said that the temperature in the fire room reaches 160° to 180°F. on the trans-Atlantic liners, and the temperature in the fire room of the old Texas in Cuba during the Spanish-American War is said to have risen to 198°F. These temperatures are exceptional. On the large ships of the Navy the fire room temperature seldom rises above 125°F.; more often it is about 110° on the coal-burning ships and even less on the oil burners.

The coal is brought from the coal bunkers and dumped on the cast-iron bilge plates which constitute the deck of the fire room. The firemen then shovel the coal into the furnaces or slice the fires as occasion may require.

During the process of throwing coal upon the fires and slicing the fires much heat is radiated out through the open furnace doors. A certain amount of ash and coal dust, as well, is thrown into the atmosphere. The removal of the heated air is accomplished through exhaust fans and through the interval between the smoke pipe and the smoke-pipe casing through which heated air rises. The fires are burned under: (*a*) Natural draft; (*b*) Forced draft.

(*a*) Under **natural draft** conditions, all of the openings leading to and from the fire room remain open, thus permitting the entrance of air to the fires under natural conditions.

(*b*) **Forced draft** is employed when for any reason it is desired to

generate steam more rapidly for power or speed. When operating under forced draft all natural openings are closed, and air is forced through supply intakes into the closed compartment, there being no outlet except through the furnace doors, *i.e.*, over the fires. This increases combustion and heat generation. Under forced draft the air

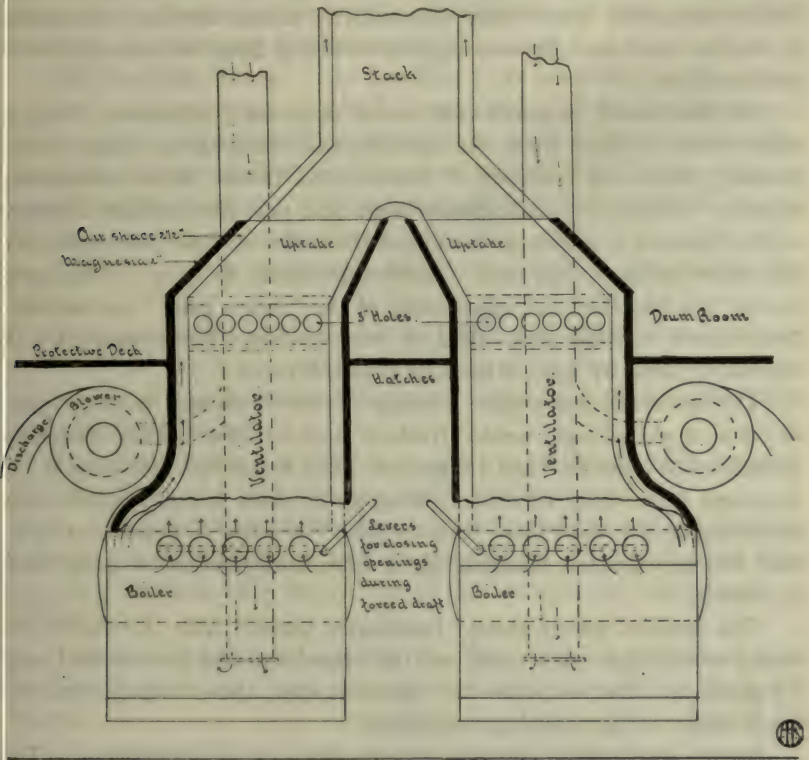


FIG. 56.—This sketch shows the blowers at the base of the smoke pipe, connections enabling forced draft, and the interval between the smoke pipe and smoke-pipe casing. The arrow shows the direction of air current in this interval. (*Gatewood.*)

pressure within the fire room is increased several inches, waeer gauge, above the surrounding atmospheric pressure, and this excess of fresh air, together with the velocity at which the stream of air is supplied, causes the temperature in the fire room to be lower than it would be if natural draft were being used. As the stream of air rushes from the

louvers of the supply ducts to the fires a stream or current is established which causes eddying in remote corners, but prevents thorough aëration of the fire room.

The work in the fire room is very heavy, and tends toward production of hernias, also myalgia is common among the fire-room force working under high temprature who expose themselves to cold drafts for relief from their discomfort. Burns are not uncommon in the fire room and likewise injuries resulting from the blowing out of gauge glasses.

As their work is performed under artificial illumination the fire-room force is taken from the sunlight and fresh air on deck; consequently, there is a tendency to anemia and disease of the respiratory system. These men also show a high rate per thousand for diseases of the digestive system and diseases of the infective type (non-venereal), the rates being 110.45 and 134.66 respectively in 1917. At general muster the bleached-out appearance of the "black gang," as the engineer's force is sometimes called, is very striking when compared with the ruddy, healthy tanned faces of the deck force.

The fire-room force after coming off watch should be encouraged to come on deck to get needed fresh air and sunlight. They should be permitted to come in clean dungarees. The writer has seen men of the fire-room force deterred from coming up on deck to rest because they were required to shift into clean "whites" in order to appear on deck, and this necessitated changing again into dungarees before going back on watch.

The medical officer should familiarize himself with the conditions under which these men work and the knowledge can be obtained only by going into the fire room and spending time there making observations under actual working conditions.

Sweat, discomfort, and dirt are the price of this knowledge. The conscientious medical officer must obtain it.

The problem of supplying fresh, cool drinking water to the fire-room force has not yet been solved satisfactorily. A portable water cooler, having a bubbling well faucet and in which a positive air pressure may be developed has been used and discarded. The drinking terminals of such apparatus are difficult of operation because of the amount of coal dust which settles upon the terminals, and even where such scuttle-butt arrangements have been installed, preference is given by the men to a bucket or pitcher containing ice and drinking cup or glass. This com-

mon drinking cup should be discouraged, and every man should have his own glass. Formerly the use of barley water was much in vogue among stokers but its use appears to have become less frequent.

Provision should be made in the fire room for proper disposal of excreta.

The bilges under the fire room should be inspected frequently by the medical officers to insure that nuisances are not being committed, and that the bilges are dry and sweet.

The Handling Room.—The handling room is located at the base of a turret and is the space in which charges and shell for the turret guns are placed in the ammunition hoists to be sent up to the guns. The shell and charge weigh several hundred pounds each, and as they are being brought from the adjacent magazines crushing injuries to the feet and hands of the men often occur.

Also injury is not uncommon among those working the ammunition hoists.

Grave accident has resulted from flare-backs after turret guns are fired. When the breech was opened grains of burning powder fell from the breech, dropped upon waiting powder charges in the handling room and caused explosion.

The above-mentioned injuries are more apt to occur when competition in drills is high and men are working at top speed.

To prevent danger of flare-backs steel shutters have been installed between the handling room and the guns above. These shutters open and close automatically as the car of the ammunition hoist passes up and down.

As a further safeguard against the "flare-back" a positive air pressure is placed in the turret guns, and when the breech of a big gun is opened the outrush of air through the gun carries away through the muzzle burning grains of powder and gases of combustion also.

The illumination of the handling rooms and shell rooms should be adequate to prevent accident. The air in the handling room and the spaces occupied by reserves in the powder division soon becomes perceptibly "close" after brief period of occupancy. On most ships this could be improved.

The Ladders.—The ladders on board ship are vertical or inclined. They may be a potential source of infection with the filth- and sputum-borne diseases. In ascending and descending the vertical ladders, the rungs must be handled. While on the inclined ladders, the hand rope

or railing must be handled by those using the ladders. If hands are soiled with sputum, urine, feces, or pus, infection may be spread.

Formerly the treads of the ladders were of cellular construction and made of galvanized iron. The construction would resemble the greatly magnified horizontal section through a wasp's nest. These ladders were found to be difficult to keep clean and were very dusty. They have been superseded by a composite tread made of alternating strips of galvanized iron and wood, the former being about a quarter of an

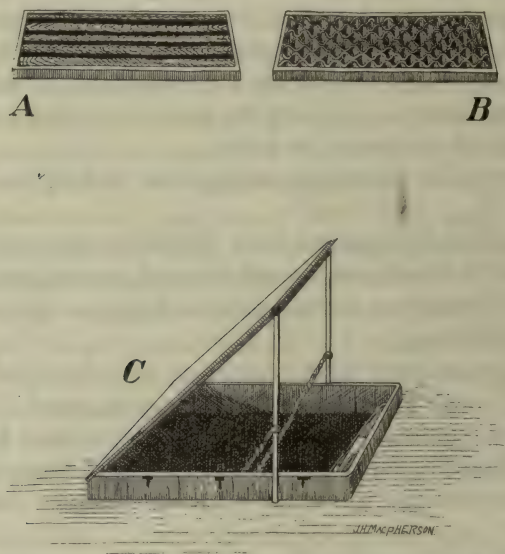


FIG. 57.—*A* represents a composite ladder tread made of strips of iron and wood bolted together. This is a much more sanitary tread than the cellular metal tread, *B*. *C*, a hatch, its cover, the ladder leading down from it and the hand-ropes for use of those descending the ladder.

inch in width and the latter at least 1 inch in width. This tread has been found to be very durable, is easily cleaned, and gives a more secure footing. When for purposes of cleaning the ladders are unshipped from the hatches the latter should be barred to prevent persons attempting to descend by the usual route. Coming from bright light on deck the eye looking into the darker hatch sometimes fails to detect the absence of the ladder.

The Galley.—The ship's kitchen, or galley, should be effectively screened against flies. It should be situated on the upper deck in or-

der to secure a maximum of ventilation at all times and to be as cool as practicable in warm weather.

The ranges should be covered with hoods in order that the odors of cooking food may pass with the heated air up through the ventilating pipes. The ranges are heated by coal, oil, or electricity.

The various cooking utensils and interior of the galley should be kept scrupulously clean and a constant war should be waged against the German cockroach which, like the poor, is always with us.

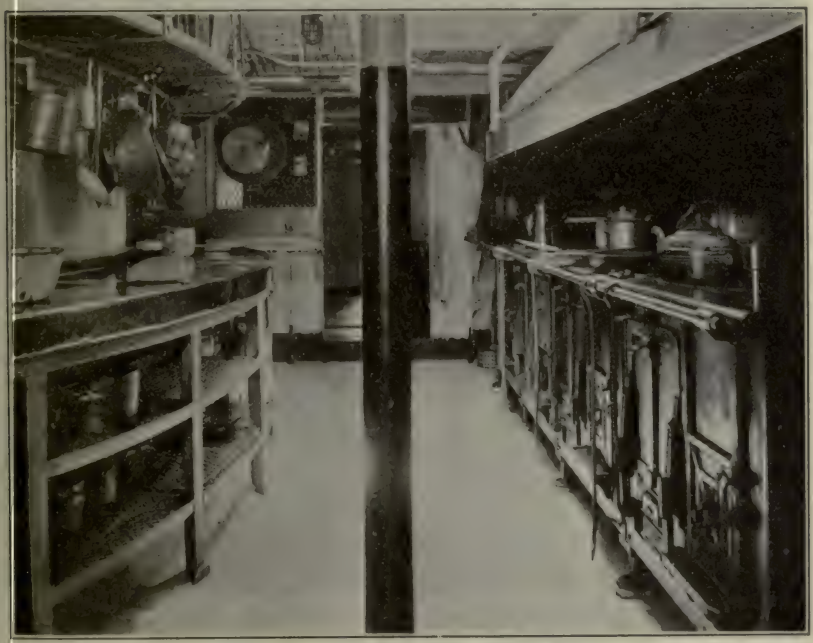


FIG. 58.—Officers' galley or kitchen.

Abundant supply of hot and cold water, as well as live steam, should be supplied to the galley and no salt water connection should be permitted. The employment of the latter might result in introduction of polluted harbor water and filth-borne infections.

The personnel of the galley should be sound in body and clean of habit. Each member should be examined to determine whether he is a typhoid carrier, and if found to be such he should not be permitted

to work in the galley. Those suffering with tuberculosis or other communicable disease should be excluded.

The members of the galley force should be inspected weekly to determine the presence of concealed venereal disease, and should be cautioned to report for treatment immediately upon feeling indisposed. The spread of diphtheria, Vincent's angina, and the like may be prevented by attention to this detail. Persons having a skin

FIG. 59.—The galley of the general mess on board ship. Note the "coppers" for boiling foods. The deck is of white ceramic tile.

disease (especially a suppuration) or injuries to the hands should not handle food. The tendency to wash personal linen and dry it in the galley should be nipped in the bud, and loafing, smoking, and sleeping in the galley should be prohibited.

The Bakery.—The bakery should be located on the main deck where there is adequate escape for the heated air which would be uncomfortable between decks.

The floor should be tiled. An abundant supply of fresh water—

hot and cold—should be available. The ranges should be heated by oil or by electricity, preferably the latter. The dough mixer should be carefully cleaned after each use as should be the mixing tables. The pans should be scrupulously clean and should not be permitted to contain the charred remains from previous bakings. The bakery should be supplied with fresh water not warm enough to interfere with the action of the yeast. At times the mixing of the dough

FIG. 60.—The meat slicer in the galley of the general mess.

with water which is too warm interferes with the normal rising of the bread. Bread lockers should be of metal. The interior should be easy of access to facilitate cleaning, and no woodwork should be permitted as it offers breeding places for the German cockroach. The bakeshop should be thoroughly cleaned with hot water each day and no filth should be allowed to accumulate in corners for the support of vermin. Corners and angles may well be sprayed with a steam hose once each week. Dish towels and utensils used should be kept clean. Towels should not be stowed wet.

The personnel of the bakery should be free from infectious diseases, and should not be permitted to smoke, eat, sleep, wash clothing, or stow it in the bakery.

All windows and doors should be screened against flies.

The handling of bread should be done in a clean manner and when issued to mess cooks they should not be permitted to receive it in their sweaty arms or upon soiled sleeves. The bread should be put upon trays and transported to the mess tables.

FIG. 61.—The bakery. Pouring dough from the mechanical mixer.

The Barber Shop.—Supervision of the barber shop by the medical officer is an important duty, the careful attention to which will prevent spread of infectious disease. The following regulations are suggested for control of barber shops on board ship, they having been prepared and found satisfactory during my service on the U. S. S. North Dakota:

1. No barber shall shave a man when the surface to be shaven is broken out or inflamed. The name of any such man shall be furnished

the surgeon and the man directed to report to the surgeon. The surgeon will advise the barber whether it is safe to shave the man in question. The same regulation applies to any man whose scalp is inflamed or broken out.

2. No person suffering from a venereal disease or any communicable disease shall be permitted to act as barber.

3. Each barber shall wear a clean washable apron or coat.

4. Towels and wash cloths used in the service of each man must be freshly laundered before use upon another person.

FIG. 62.—The bread room. Note the mechanical bread slicer at the extreme right.

5. Dusters shall not be used. The necessary wiping away of cut hair from face and neck shall be done by means of a clean towel or a clean wash cloth.

6. Alum or other material used to stop flow of blood shall be used in powdered or liquid form only and shall be applied on a clean towel.

7. Either a clean towel or clean new paper shall be used on the head rest for each man.

8. No powder puffs or sponges shall be used on any man.

9. Each barber shall wipe his hands after each shave or haircut with a towel moistened in a disinfecting solution, or wash his hands immediately before serving any man.

10. Hair brushes shall be washed daily and disinfected in the formalin chamber.

11. The barber shall sterilize all mugs, shaving brushes, razors, clippers, scissors, tweezers, needles, lances, combs, and soap before each

FIG. 63.—Baking pies for the crew.

separate use, by immersion in boiling water. Razors must be dipped in boiling water after stropping and before each use.

12. The surgeon will furnish the head barber with a list of men who are under treatment for dangerous venereal or other contagious disease, and such men if permitted to be served by any barber shall have each his own separate razor, comb, brush, clippers, etc., which on no account shall be used on any other man.

13. The barber shop shall not be used as a berthing or sleeping space.

14. The removal of cut hair from the deck shall be done in such manner as to produce a minimum amount of dust.

The Brig.—Prisoners in the "brig" or ship's prison should be visited by the medical officer twice daily, morning and evening; should have proper exercise prescribed for them; and if on reduced rations should be the subjects of special care. "Bread and water" never is justifiable.

Before confinement, for a period longer than ten days, upon sentence of court-martial, the sentenced man must be examined by the medical officer, who is required to certify over his signature that the sentence imposed will not seriously impair the health of the prisoner.

Care must be taken that the nutrition of a man so confined shall not suffer.

When an intoxicated man is placed in the "brig" to sober up, the medical officer should satisfy himself that the man's physical condition is good. Men profoundly poisoned with alcohol have died while so confined.

The medical officer should always satisfy himself of the suitability of a space before permitting men to be confined in it. The minimum dimensions of space for confinement of a prisoner are fixed by U. S. Navy regulations as follows:

"Not less than 6 feet long and 3½ feet broad with the full height between decks and shall be properly ventilated. They (these spaces) shall not be altered without authority of the Navy Department."

It is further provided by U. S. Navy regulations that prisoners shall not be confined in spaces other than those designated by the Navy Department, except in cases of necessity, when "The medical officer shall be called upon to report whether such spaces are fit for prison use."

The prescribed dimensions of the brig guarantee adequate cubic space for each occupant. The entire interior surface of the brig should be made of steel which should be thoroughly cleansed after each occupation. The space should be lighted by indirect electric lighting, the fixtures being attached to the deck above and covered by a strong grating, so that should necessity arise a maniac could be confined without endangering himself or the installation. The lights should be controlled from outside.

Since men who are confined in the brig are restrained from following their own inclinations, even necessities, the ventilation and heating

should receive especial care, and the ducts supplying fresh air, whether heated or not, should be controlled so that unauthorized tampering with the supply will be rendered impossible.

Special care also should be exercised that persons confined in the brig are sufficiently clad, have an adequate supply of bedding, and are fed and policed regularly.

The brig spaces should be so constructed as to prevent access of unauthorized persons. Smoking should not be permitted, and the medical officer should assure himself that persons in confinement have regular baths, clean clothing, and under proper guard are given opportunity to exercise in fresh air and daylight, especially if the period of confinement exceeds more than a day or two.

Effort should be made to prevent physical suffering on part of those confined, yet the brig should not be made a comfortable asylum for shirks and ne'er-do-wells.

The Butcher Shop.—The butcher shop should be located in the superstructure on the weather deck where it will get as much fresh air and sunlight as possible. Its deck should be tiled in order that drippings from the meat may not be absorbed but may be readily cleaned. Doors and windows should be screened as should be the terminals of the ventilating system entering the butcher shop. If screening is impracticable the shop should be kept dark during day time in order that flies may not be attracted.

Meat should be drawn from the cold storage at a fixed hour morning and evening and taken to the butcher shop to thaw and be dressed and prepared for the galley. While thawing, the meat should be left in its wrappers and should not be permitted to lie on the deck. Meats usually are inspected before being placed in cold storage and in the U. S. Navy bear the stamp of a meat inspector of the Bureau of Animal Industry of the Department of Agriculture. These meats are inspected also by the medical officer immediately before being taken on board ship. If, however, when thawing has taken place the meat appears to be of questionable quality the medical officer should be notified at once in order that his opinion and recommendation may be had.

Partially decomposed meat and trimmings which cannot be utilized as food should be thrown overboard or incinerated, and bones which cannot be utilized in the soup kettle should be similarly treated. Scraps of meat should not be allowed to stand uncovered in the butcher shop. They should be disposed of as necessity may indicate,

but not left to decompose and attract flies. The surface of the meat block should be frequently scraped, scrubbed, and kept smooth.

Instruments including the meat grinder should be kept scrupulously clean. The deck should be regularly scalded with a steam hose to cleanse it and to prevent breeding and presence of insects. The drains should receive especial attention. If necessary, permanganate of potash solution, 1–500, or a solution of chlorinated lime may be poured through the drains to deodorize. Deodorizers may be used on occasion,

FIG. 64.—The butcher shop. Meat from cold storage thawing. Note ceramic tile deck.

but should not be permitted to replace ordinary cleanliness. The odor of decomposing meat should be prevented in the butcher shop in order that tainted meat may be recognized more easily.

Personnel of the Butcher Shop.—The butcher and his assistants should be frequently inspected for the presence of disease, and no disease carriers should be allowed to assist in the preparation of food. The butcher should be required to keep his person and clothing scrupu-

lously clean, using fresh apron and towels daily. Soiled linen should be removed from the butcher shop. Clothing and personal effects should not be stored therein, nor should sleeping in the butcher shop be tolerated.

Hot running water should be provided in order that instruments and hands may be washed frequently. Persons having injured or sore hands should report at once to the medical officer and should be relieved from duty in the butcher shop until well. Loafing in the butcher shop and unnecessary traffic through it should not be allowed. Pets should be prohibited.

The Laundry.—The laundry on board ship usually is under the supervision of a commissioned officer who is responsible to the captain for its efficiency and for the execution of sanitary recommendations made by the medical officer.

The medical officer should inspect the laundry frequently, making unexpected visits, and base his recommendations upon his observations.

The laundrymen should be clean of person and clothing, and should be inspected by the medical officer weekly. Disease carriers should not be permitted to handle laundry. Sleeping in the laundry should not be permitted. Loafing should not be allowed and no unauthorized persons should be permitted to work in the laundry. Sickness among the laundrymen should be reported promptly to the medical officer. Food, insects and pets have no place in the laundry.

Linen from the sick bay should be carefully disinfected before being sent to the laundry and a certificate to that effect signed by the medical officer or pharmacist should accompany it. The medical officer should prevent the sending of linen to the laundry by any person known to suffer from contagious or infectious disease until the washing has been disinfected. In so far as practicable the soiled linen should not be permitted to come in contact with fresh linen, and never should it be stowed in the laundry, but linen to the capacity of the laundry should be received at a definite hour, after which no soiled linen should be received until that already in the laundry has been washed, ironed and delivered. The receipt of washing should be so arranged that all linen in the laundry at any one time in so far as possible should come from the same part of the ship. For instance, the washing of all officers should be taken on Monday and delivered before any other washing is received. Then linen from another section of the ship should be taken, laundered, and delivered. This method will tend to limit dissemina-

tion of bed bugs, vermin and disease throughout the ship. The laundry is a potent factor for the spread of disease and vermin, being the focus to which they may be carried in the soiled linen; particularly *vermin* may be distributed from this focus.

The apparatus should be of the latest, most approved sanitary type and should include a steam drying tumbler. The deck should be of tile or similar impervious, non-absorbent material. The walls should be white and the standing parts of the machinery should be painted white. The white paint on the standing parts enables the more ready detection of dirt and also increases the amount of light in the dark corners.

The laundry, especially if between decks, should be provided with an efficient exhaust system of ventilation for the removal of wild heat and excessive humidity incident upon the laundering processes.

Distilled or approved fresh water should be used in the laundry, and the apparatus should be thoroughly washed from time to time to prevent the accumulation of precipitated soap, epithelium, etc. The laundry should be thoroughly cleaned once each week, and gross dirt should be removed daily.

When necessary to prevent breeding and spread of vermin or to limit the spread of communicable diseases, fumigation of the laundry should be practised.

Underwear and bedding, unless made of wool, should be submerged in boiling water for a period of at least five minutes. Laundry water should not contain a sufficient amount of lye to be harmful to the fabric. Chlorine water, which is surreptitiously used for bleaching purposes, should not be permitted in the laundry because of its damaging effect upon articles bleached by it.

It is a common habit among laundrymen to sprinkle clothing before ironing it by taking water into the mouth and spewing it over the garment to be ironed. This pernicious habit should not be tolerated. An appropriate spraying apparatus should be provided and its use required.

A rose spray attached to a large rubber bulb similar to that used in florists' shops for sprinkling flowers is the best method. An ordinary whisk broom dipped in water may be used.

The "sprinkling can" frequently used is mentioned to condemn it. This can has a spout with a rose spray on its end and a second spout

or mouth-piece through which the laundryman may blow into the can and force water out through the first-mentioned spout.

Infection of the clothes may result from saliva which entering the water may be sprayed upon a garment *after it has been* exposed to the heat of the laundry and drying processes.

It has been shown that the brief exposure to heat during the ironing does not sterilize infected fabric, but Schroeder and Sutherland (*Public Health Reports*, 1917, vol. 32, p. 225) have shown that wet clothes infected with bacteria are generally sterile after passing through tumblers, mangles, drying rooms, and hot pressing or ironing.

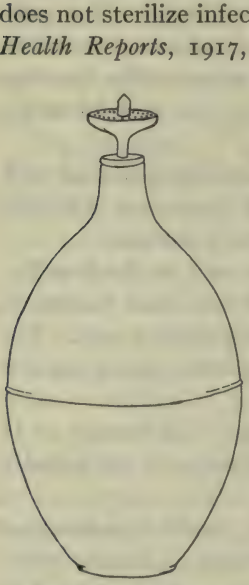


FIG. 65.—A rose spray used by florists makes an excellent instrument for sprinkling.

Care is to be exercised that the mass of soiled linen is in the water sufficiently long to permit penetration of the boiling water to the center of the mass of clothing.

Steam laundries are far more sanitary than hand laundries. Towels in daily use by men on board ship often are not properly dried because of lack of proper and convenient clothes lines. Clothes lines should be conveniently placed in order that the damp towels may not be stowed away.

Members of the crew frequently wash their own clothing in the wash room or on deck in galvanized iron buckets. Clothing thus washed should be carefully dried, and the water used by one man should not be used by a second for the washing of the clothes of the latter. The soapy fresh water in the bucket may be used by several men unless effort is made to instruct members of the crew concerning the danger of this violation of hygienic laws.

The clothing should be dried in the sun when this is practicable because of the bactericidal effect of sunlight. This method of drying however is usually impracticable and recourse must be had to the steam drying room, or preferably the drying tumbler.

The Steering Engine Room.—The steering engine room situated in the after-part of the ship and well below the water-line is uncomfortably hot and humid when steam is on the steering engine. This compartment is lighted artificially and those whose duties keep them in the

steering engine room should be required to spend as much time as possible in the light and air on deck.

Steering engines driven by electricity are far less reliable, consequently steam must be used despite the discomfort resulting. Close watch should be kept upon the physical condition of the steering engine crew who work under enervating conditions which predispose to colds. Nervous persons should not be allowed to go on this duty since the noise is great at times and commences with startling suddenness.

Coaling Ship.—Coaling ship is **disagreeable** and **dangerous.** It is *disagreeable* because all of the living spaces must be made as nearly air-tight as possible with a view to prevent entrance of the cloud of coal dust in which the ship is enveloped during coaling. Ventilation is interfered with. There is disturbance of the regular routine, and coal dust is everywhere.

When possible coaling is usually begun just so soon as daylight will enable operation of the machinery, and the process is continued often late into the night in order to complete the coaling in a single day.

The deck spaces are cluttered with piles of coal and the gangways are filled with processions of black-faced men trundling wheel barrows laden with coal. In threading one's way about on deck coal dust is apt to be so much as an inch deep, and the nasal and respiratory mucosa as well as conjunctiva are much irritated by the cloud of coal dust.

Coaling ship is *dangerous* because powerful machinery carrying heavy loads are handled at top speed in order to complete the disagreeable task. Coal is hoisted from colliers in bags containing a half ton each. One load from a single cargo boom consists of 5 bags or $2\frac{1}{2}$ tons. The contents of these bags are dumped on the deck about the mouth of the cylindrical coal chutes and groups of grimy men shovel the coal rapidly into the chutes, trying to clear the deck before the arrival of another $2\frac{1}{2}$-ton load. As these heavy loads of coal swing through the air, the careless man or the heedless one may be struck as the load swings round. Serious injuries occur in this manner, especially toward the end of the day when the men are tired.

The manipulation of the machinery has its dangers and the skylarker or careless man is apt to injure or be injured.

During the coaling in the early morning or at night accidents occur as result of men walking into the mouths of the chutes through which the coal is being shoveled. The mouths of these chutes are generally

marked when the manhole plates are off, but the accidents are apt to occur in the half light when the markings are not readily seen.

At the bottom of the chute the coal is received into the bunkers and is "trimmed." If the lumps are large the trimmers may be injured as result of the lumps falling 15 or more feet and striking them. The work of the trimmers is very arduous. They have little ventilation in the bunkers and an ever-diminishing volume of air as the bunker fills with coal. Such air as is available is heavily laden with coal dust.

During coaling all hands are required to remain on board. Before coaling commences the medical officer should see that as many first-aid parties as he may deem advisable are stationed in accessible positions on deck. The hospital corpsman in charge of each party should have stretcher, tourniquet, and first-aid dressing ready for immediate work. At least one medical officer should remain below decks and keep as clean as possible in order to be ready to operate at once in cases of grave injury. The operating room should be supplied with an abundance of dressings prepared for emergency.

The commissary department should supply meals as nearly on time as possible, and if the coaling is begun in the early morning hot coffee should be served before commencing. As coaling is very laborious additional rations should be provided.

The playing of the band at frequent intervals is desirable for its psychological effect upon the workers.

Medical officers should watch the men to prevent undue exposure. In winter or in rainy weather men coaling ship frequently are insufficiently clad. Not desiring to ruin good clothing for which they have paid, they tend to dress in as few clothes as possible, and easily become chilled as they are often drenched with perspiration during work.

After coaling ship an abundance of fresh warm water should be available to the men who must commence at once to scrub the ship inside and out. It takes a day or two before the ship is clean once more.

Conjunctivitis, irritation of the respiratory mucosa, cuts, and bruises remain to be treated by the medical officer.

"Coaling ship" is a very simple matter on vessels using fuel oil. The turning of a valve permits the oil to run into the tanks and the arduous labor, dirt and discomfort of coaling are avoided. Precaution should be taken to avoid fire while handling oil.

Small Boats and Boating.—Attendant upon large ships are a number of small boats. These vary in size and character from the ungainly

flat-bottomed punt propelled by a single scull which is used by the side cleaners or men working on the ship's side near the water level, to the picket boat or large, swift, steam launch. Many of the ship's boats are driven by gasolene motors, some of these motor boats being sufficiently large to carry 100 to 120 men. The ship's boats are hoisted on board by powerful cranes, and when possible are nested within one another in cradles, a canvas cover being lashed over all to protect them from the weather. Frequently members of the crews

FIG. 66.—Repairing targets is a dangerous phase of small boating. Frequently a heavy sea is running, men fall overboard or are otherwise injured. They should be good swimmers. Much exposure is involved in this work.

of these boats, which are lying in the cradles, live in their boats in preference to occupying the billets assigned to them between decks. In the boats they are well protected from the wind, and are in the fresh air, although there is no heat if the weather is cold. These men, if occupying gasolene motor boats, may suffer from inhalation of gasolene fumes due to leakage from the gasolene tank. The fumes may be confined within the boat, under its canvas cover, and may

attain concentration sufficient to produce gasolene "jag." I have seen two fires which originated from explosions caused by the striking of matches within a boat lying in the cradles.

Inspection of the nested boats should be careful and thorough, for the seclusion afforded by the boats enables their occupants to indulge in harmful practices if they are so inclined.

When ship's boats are in the water their crews often suffer considerable exposure to heat, cold and wetting, and in heavy seas there is danger of the foundering of small boats and drowning of occupants.

FIG. 67.—Spreading targets.

The members of the boat's crew should be expert swimmers, as they are not infrequently overboard, accidentally or by intent, as for instance when going over to clear a fouled propeller. Members of the boat's crew should be provided with rain clothes and should be warmly clad for protection against winter weather. In summer and in the tropics, the boat's awnings should be spread between the hours of 9:00 a.m. and 5:00 p.m. for protection against the direct rays of sun.

Running boats' crews often suffer as a result of irregular meal hours and lack of opportunity to answer the calls of nature. Observation

leads the writer to believe that the members of the boats' crews have insufficient time to eat.

When mess gear is sounded, even if the boat is at the boom one or more members of the crew must remain in it as boat keepers while the

FIG. 68.—A Jacob's ladder. Pendant is ommitted from illustration.

others go aboard to eat a hurried meal. Having eaten they return to the boat and relieve those who have been left behind who in turn go to their mess. These two groups of men from the boat's crew eat their meals during a single mess period—that is, two men eat in succession

during the time allotted for the meal of one individual. Boating at times is very hard work, and entails a maximum of effort and muscle strain, as for instance when a bow man tries against tide and wind to hold on to the ship's side, with his boat hook. Hernia is apt to be produced as result of such strain. When boats are hauled out to the boom and are there made fast there is often considerable danger to the members of the crew as they attempt to leave the lurching boat, going over

FIG. 69.—Swimmers going up the Jacob's ladder and standing on the boom.

the Jacob's ladder and boom to reach the ship. Considerable danger also attends the transfer of heavy stores from the boat to the ship. Often these stores are placed in a cargo net and hoisted vertically out of the boat to be swung inboard on to the deck. Should the cargo net give way its load would be precipitated upon the boat below. While attached to the U. S. S. Arkansas at Guantanamo Bay, I treated a man who was injured as a result of accident to the hoisting apparatus. He was struck by a hind quarter of frozen beef which fell from a distance

of not less than 20 feet, fracturing his femur and producing severe injuries about the head and face.

Boats leaving the ship always should be provided with a supply of fresh drinking water in a "breaker" or keg and tinned biscuit. In pulling boats, and especially race boats, hernia may be produced by straining at the oars. In patrol and picket boats, especially the 110-foot patrol boats, exposure during the winter is extremely severe. The methods of heating these small vessels are impracticable and much suffering is experienced by those engaged in the patrol work.

FIG. 70.—Accident may happen as result of the gunwale of the boat being caught under the accommodation ladder. Note the bow man "holding on" with a boat hook.

One has to see these small craft covered with ice coming in from a tour of duty and bringing in an exhausted crew to realize the hardship of this patriotic service.

Finally, a word must be said concerning the danger of crushing between boats and gangways or floats alongside which the boats may be making a landing. The boats carry weigh or momentum far greater than is realized by a landsman, and the novice at boating is very apt to get fingers crushed or lacerated, or an arm or a foot crushed, by forgetting to clear the gunwale as a boat comes alongside; also, in a sea way, the small boat rising and falling with the sea may crush the leg of an individual who attempts to jump from the small boat

to the landing stage, as the boat goes down from the crest of a passing wave.

Ship's boats should not be overcrowded in going to and from the ship, and especially should care be exercised to see that liberty parties returning from the beach trim the boat so that the weight will be properly distributed throughout.

Serious accidents have resulted from the improper loading of small boats, men heedlessly rushing down into the boat and paying no attention whatever to the trim.

When the boat heads out from smooth water and strikes the sea, it may overturn and life may be lost. During coaling and occasionally at other times, small boats may be sent away from the ship to remain overnight at a dock or inshore. The medical officer should see that the crews of such boats are provided with food, water, proper covering, and if in a locality where mosquitoes are prevalent, mosquito nettings should not be forgotten.

The side cleaners who work in punts alongside the ship often are exposed to wetting and chilling, their clothes and shoes becoming thoroughly wet. Rubber boots may be worn and the clothing should be changed at the earliest opportunity.

When the boats are being "hooked on" to be hoisted on board ship there is often much danger to those who are attending to the work, especially those in the boats. Formerly this hoisting was done by hand; now it is done principally by large cranes operated by electricity. As the small boat comes alongside to be hoisted aboard unless care is exercised it may be dashed against the ship's side with danger to life and the boat as well. Also, the hoisting tackle is heavy and unless it is dextrously handled and the hoisting is commenced quickly, one end of the boat may be raised, while the fall on the other end, not having been caught in the ringbolts, fails to hoist. When hoisting is done by hand one end of the boat may be raised more slowly than the other as the groups of men manning the two falls vie with each other in hoisting. If a fall carries away, boat and occupants may be precipitated into the water with serious result. An accident of this character happened on board the ship to which I was attached in the harbor at Colon. The occupants of the boat were thrown into the sea. No lives were lost, but serious injury followed their being struck as they fell. At sea it often becomes necessary for a big ship to maneuver for a lee in order to enable one of her small boats to

hook on. When boats are to be hoisted a minimum number of men necessary to hook on should be permitted to remain in the boat, all others should be sent aboard. In steam launches burns and injuries

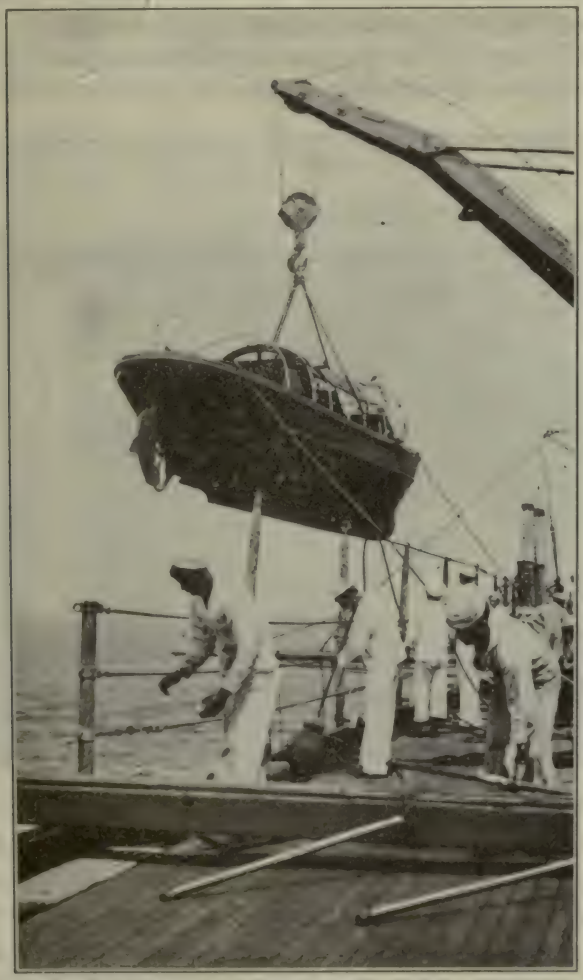


FIG. 71.—Hoisting a big forty-foot steam launch from the water into its cradles on deck.

frequently occur, as for instance the blowing out of gauge glass, scalding, or burning while handling the fires when the boat is in a seaway.

Bedding.—On board ship the crew sleeps in the hammocks made of canvas suspended from hooks on the deck beams by means of hammock clews. In the hammock is a mattress made of kapok, a highly inflammable vegetable substance, the best of which is obtained from *Ceiba pentendra,* a tree grown in Java.

Kapok is very light and on account of its buoyancy may be used as a life preserver as well as for a mattress. This mattress is covered

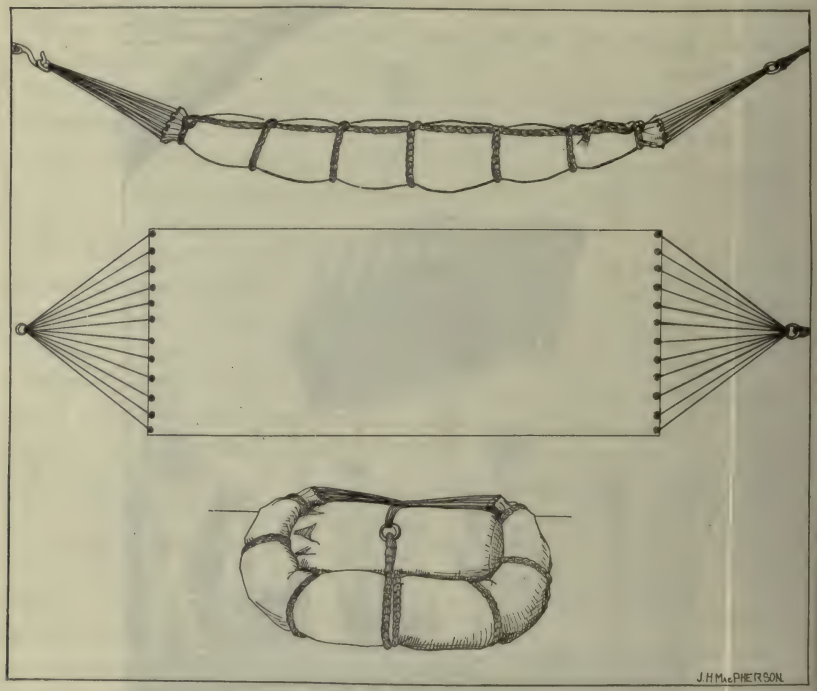


FIG. 72.—A hammock rolled and lashed. A hammock spread. A hammock and clothing bag securely lashed together for transport.

by a cotton mattress cover having reinforced felled seams. The mattress slips into the cover which is tied together at one end with tapes. The mattress cover being washable serves to protect the mattress as sheets are not used. Woolen blankets are used as covering.

Upon arising in the morning the hammock is rolled into a neat roll, securely lashed and stowed in the hammock nettings. The latter should be made of steel and all cracks should be thoroughly filled to

prevent the harboring of vermin. Wood should not be used in the hammock nettings.

The ship's routine requires that the bedding be aired Friday of each week, the weather permitting. When the hammocks are brought out to be aired they should be unlashed and unrolled, so that sunlight and fresh air may have access to the contents. Frequently the weather will not allow the airing of bedding according to schedule and the

FIG. 73.—Men sleeping on billets in hammocks.

medical officer should be vigilant to see that this important sanitary measure is carried out at first opportunity. The medical officer should see that the divisional officers are thoroughly instructed how to inspect the bedding of their men.

When the bedding is being aired it should be inspected for the presence of vermin. The seams and tufting of the mattresses should be thoroughly examined for the presence of bed bugs as evidenced by the finding of the bugs themselves or the stains left by them. Mattresses should be selected at random for examination.

Mattress covers should be changed weekly. The engineer's force should give special attention to mattress covers. These men perform arduous labor under conditions of dirt and grease, and their mattress covers are apt to be soiled sooner than those of the deck force. Discovery of the presence of vermin should be the signal for drastic action.

FIG. 74.—A hammock and mattress properly secured on a life line during "airing bedding." A clothes line above.

At times the airing of bedding is impracticable because the direction of the wind is such that cinders from the smoke pipe are deposited on the mattresses and blankets, soiling them and often burning if the draft from the smoke pipe is very great.

The hammocks are quite comfortable. Occasionally an individual

FIG. 75.—Airing bedding.

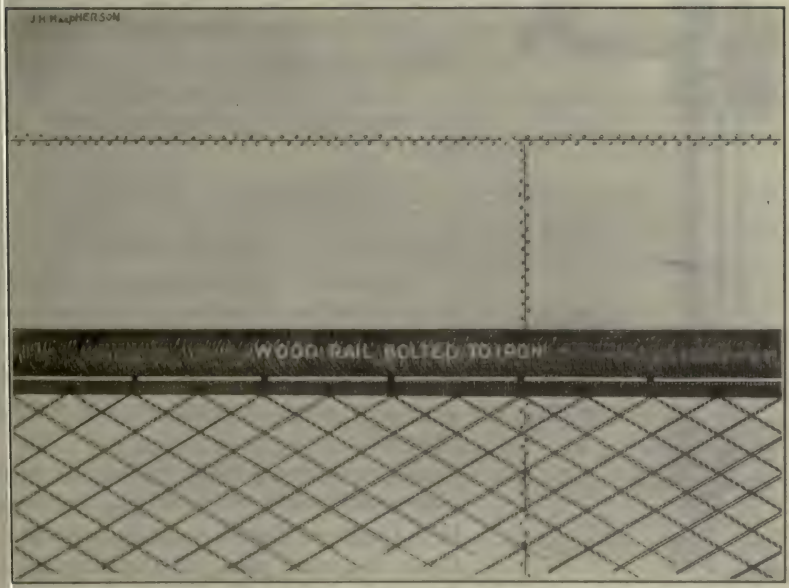


FIG. 76.—Section of the rail of a hammock netting. The interval formed as result of warping of the wood forms a breeding place for vermin. The author recommends a bare steel rail without the wood.

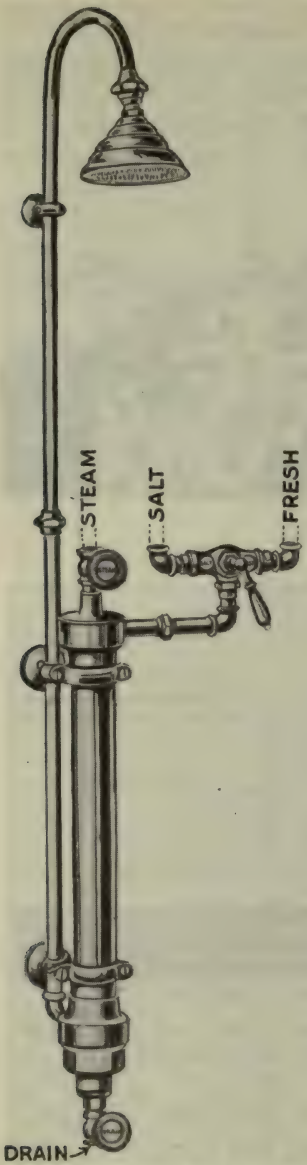


FIG. 77.—Fresh and salt water shower bath with an instantaneous heater attached. Careless manipulation may result in scalding.

is found who claims inability to sleep in a hammock but this is infrequent.

Accidents occur to sleepers in hammocks as result of the cutting of the hammock clews by a practical joker. This precipitates the sleeper to the deck and he is fortunate to escape without broken bones.

The mattresses should be kept from the deck as much as possible in order to avoid soiling.

Baths.—Cold baths are tonic and stimulating. Hot baths are diaphoretic and sedative. Aside from the therapeutic effects of baths they are desirable:

(*a*) For promotion of cleanliness;

(*b*) For maintenance of the skin's function;

(*c*) The prevention of the breeding of germs on the skin;

(*d*) Avoidance of air pollution due to decomposition of excretions from the skin.

Before going into battle all hands should take a bath and put on clean underclothing, when practicable.

Abundant bathing facilities should be provided on board ship for the crew; shower baths in proportion of one shower per 25 men, should be provided. Tub baths are insanitary and should not be allowed.

The fire-room force usually is provided sufficiently with bathing facilities in the engineer's wash room, but the deck force has not been equally fortunate. The latter have been compelled to depend largely upon such sponge baths as may be had by using a deck bucket.

These buckets made of galvanized iron will hold 3 gallons. Some showers generally are provided for the deck force, but the number is inadequate.

The Engineer's Wash Room.—The engineer's wash room is usually located immediately above the fire room so that coal passers and firemen drenched with perspiration and covered with coal dust (on coal-burning ships) may ascend directly from their stations, bathe, and wash out their steaming clothes before going out on deck. This arrangement prevents the soiling of the ship which would result were the wash rooms remotely situated.

The location of the wash room necessitates being placed between decks and inboard so that the sun does not get to it to dry and light it. Artificial illumination constantly is necessary, and unless there is careful supervision foul odors will arise from decomposition of waste products resulting from baths.

Each member of the engineer's force has a locker in which steaming clothes are kept. Unless regularly inspected, foul clothes may be permitted to remain in the lockers and vitiate the air by their odor. These lockers should be made of strong galvanized iron wire grating. This enables thorough ventilation and facilitates inspection.

The engineer's wash room should be divided into two parts, each being used on alternate days while the other is being thoroughly cleaned.

To prevent the spread of parasitic skin diseases, common use of towels should not be permitted, and a steam hose should be used freely to spray over the tile floor and wooden gratings which sometimes are used in the showers.

In the engineer's wash rooms the wooden gratings are difficult to keep clean and should be steamed daily. The drain from the wash room should be blown out with the steam hose daily to prevent the bad odor which commonly arises from this waste pipe.

None but standard soaps should be allowed. The writer has seen several cases of dermatitis due to excess of carbolic acid in a much advertised soap.

In favorable circumstances of climate and water much sea bathing is done by the ship's company (see Swimming).

Refrigeration.—Refrigeration is necessary on board ship for:

(*a*) The preservation of food;
(*b*) The cooling of the magazines;

(*c*) The cooling of water at the scuttle-butts;
(*d*) The manufacture of ice.

On board the ships of our navy refrigeration is accomplished by ice machines of the dense air type. They depend upon the absorption of heat which results from the expansion of compressed air in coils. The ammonia ice machines are both unsatisfactory and dangerous for use between decks on board ship.

(*a*) **The Preservation of Food.**—Fresh foods; meat, butter, eggs, fish and the like are preserved in well-insulated chambers lined with galvanized iron, equipped with hooks, shelves, and racks for stowing the meats. The compressed cold air is led through pipes or "coils" through these chambers. The compressed air in the pipes expanding rapidly abstracts heat from the chamber and by a proper regulation a desired temperature may be maintained constantly.

In the chambers where meat is kept a temperature below 32°F. is maintained and the meat is kept frozen stiff. Such a chamber must be very carefully watched as a failure to maintain freezing temperature will permit thawing and consequent decomposition.

Butter should be kept in a separate chamber where it may not absorb odors from surrounding food stuffs. If possible eggs should be kept in a chamber in which the temperature is 35° to 40°F. to prevent their freezing. This same temperature is desirable for preservation of fresh fruits. The lining of the chambers should be water-tight, for on the cooling coils even in the tropics a constant thick woolly coat of snow ice is deposited. When for any reason the temperature rises sufficiently to permit melting, the water finds its way through leaks in the chamber, gets into the felt insulation, and there causes decomposition and insanitary conditions.

Meats, fish, and shell-fish may be kept almost indefinitely if the proper temperatures are maintained. The writer has eaten oysters frog legs, and fowl taken from cold storage after they had been kept for three months. The articles are frozen stiff and may be handled as one would so much wood.

The refrigerators should be opened not more than twice a day fo the removal of stores. If opened oftener they are warmed up and injury to the food results. The persons entering the ice-box should b warmly dressed and should wear clean shoes, preferably rubber over shoes. The various compartments should be kept swept out b

brooms used for no other purpose. Unless attention is paid to this detail much frozen filth will accumulate. The chambers of the cold storage cannot be scrubbed while the temperature is below 32°F.

When practicable, for instance at Navy Yards, the cold storage should be emptied, thoroughly overhauled and scrubbed with lye and hot water, then rinsed out before refilling.

(*b*) **The Cooling of the Magazines.**—In order to prevent deterioration of explosives the temperature in the magazines must be maintained at a certain standard, and for this purpose connection is made with the ice machines.

(*c*) **The Cooling of Water at the Scuttle Butts.**—Drinking water for the crew is cooled in the scuttle butts by means of cooling coils which pass through the water in the scuttle butts.

(*d*) **The Production of Ice.**—A small amount of ice is made for the cooling of water in the officers' and chief petty officers' messes, for the small refrigerators belonging to these messes and for the sick bay. The amount of ice manufactured is limited to actual needs.

Sewage Disposal.—On board large ships the disposal of human excreta is a comparatively simple problem, yet certain things still are to be desired in order to render sanitary the disposal.

The "Heads" or Water Closets.—On large ships the "heads" are located above the water-line and discharge overboard through drainage pipes and scuppers.

This discharge is effected through the medium of a circulating system in which salt water is pumped through the heads, giving a continuous flow in the fixtures and washing away by gravity the excreta as they are deposited. The lips of the scuppers should be sufficiently long to direct the sewage away from the ship's side as it falls into the water in which the ship lies. The mouth of the scupper should be protected by a check which enables sewage to escape, but is closed automatically when the mouth of the scupper is struck by a sea.

Portable canvas chutes or "pantaloons" reaching down to the water from the scuppers are used when in port and protect the ship's side from fouling. The lips of the scuppers should be kept clean, else objectionable odor may be noticed on board ship near their point of discharge. Side cleaners and ship's boats should avoid coming in range of the discharge from the scuppers.

The heads for the crew usually are situated in the eyes of the ship

under the forecastle, unless the wardroom is located forward, in which case the crew's heads are aft.

The heads should have a tile deck and should contain no wood except necessary floor gratings and the seats.

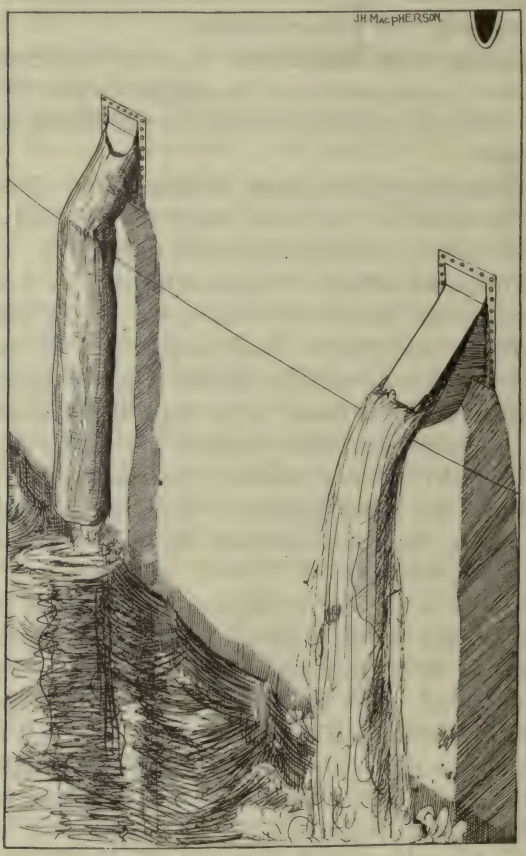


FIG. 78.—Scuppers. Sewage is being discharged from the one on the right and spatters or is blown by the wind. On the left a portable canvas pantaloon enables discharge at the water level.

The heads should be sufficiently large to enable division into two halves, each half being in use by the crew while the opposite half is being cleaned and prepared for the next day's use.

Accommodations should be provided for 10 per cent. of the crew un-

less urinals are to be provided in addition. In this case one urinal should be provided for each 15 men. Of the 10 per cent., 5 per cent. should be in daily use while the other 5 per cent. are being cleaned, *e. g.*, a battle ship having 1200 men should be provided with 120 seats, 60 of which are in use while the remaining 60 are being cleaned. Greater privacy is desirable in the crew's heads. Screens are used but they interfere:

1. With ventilation;
2. With cleaning;
3. With careful inspection; and,
4. They afford opportunity for pernicious practices.

Water closets should be ventilated thoroughly by the exhaust system, and automatically flushed.

Space, weight, cost and simplicity have determined that the best type of fixture for the crew's head is a trough of appropriate size made of porcelain or tin-lined iron or of plain cast iron gently pitched to the waste pipe and through which a stream of salt water is constantly being flushed. This trough may be used as a urinal and when the seats are in place may be used for defecation. The trough should be so shaped that feces will not fall on and adhere to its sides.

The best type of seat is that which is divided into two distinct halves, being split in the middle in front and behind, each half is hinged so that it may be raised if the individual does not desire to sit upon it. The halves should be removable and should be unpainted. Dressed ash is the best wood for the purpose. The seats should be taken off during the day for cleaning, sprayed with a steam hose and thoroughly scrubbed. The spraying with a steam hose is for the purpose of killing microörganisms which may have soiled them or killing vermin if such exist.

After considerable experience the writer is sceptical as to the alleged frequency with which pediculi are contracted in water closets. On inspections he has never seen a louse on a water-closet seat, and it is doubtful if a self-respecting louse would desert board and lodging for an inhospitable water-closet seat.

During the process of cleaning the steam hose should also be sprayed over the trough. Seats which are cracked are insanitary and should be removed at once.

The medical officer should keep in touch with the captain of the

head, and carefully instruct him as to the great importance of his duties. The captain of the head, if properly approached may be able to give the medical officer valuable information concerning concealed disease or vicious habits observed or suspected by him in the performance of his duties.

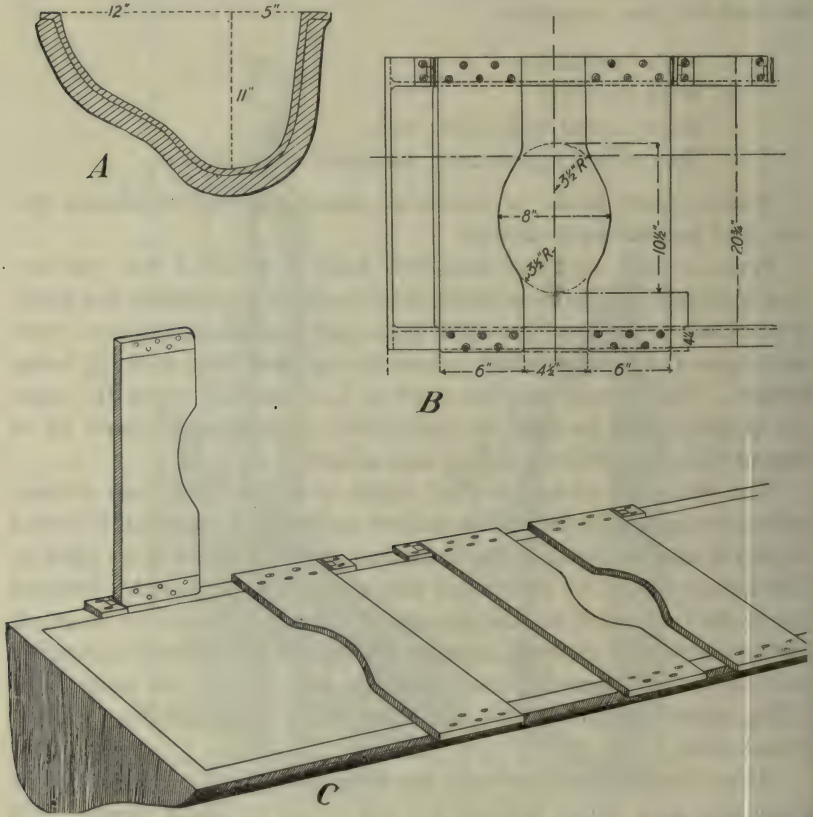


FIG. 79.—*A*, A transverse section of *C*, the trough over which water-closet seats are placed. *B*, detailed drawing of water-closet seat.

An abundance of toilet paper should always be at hand and no ships' head should be constructed which does not include a lavatory with foot or knee controlled faucets at which soiled hands may be rinsed before leaving the closet to handle door knobs, hand rails, etc. Bibulous paper towels should be supplied.

Lelean mentions the case of a forecastle hand who was a typhoid carrier to whom 13 cases of typhoid were traced as result of the common use of a vertical ladder, the carrier being careless in cleaning his hands after visiting the water closet.

The water closets for the officers should be well ventilated, provided with toilets automatically flushed, or of the pump type, and porcelain

FIG. 80.—A pump type water closet used in the officers' toilet.

urinals. The toilets should have porcelain bowl with varnished hardwood seats and should be so constructed as to prevent the soiling of the user by regurgitation of air and water when the ship pitches or rolls, and the mouth of the scupper suddenly becomes submerged. The floor should be tiled and the space alloted for each separate toilet should be sufficiently large to prevent constrained positions.

All water-closet seats should be as low as cleanliness will permit. The base on which the feet of the occupant rest should be not more than 6 inches below the level of the toilet seat. This approximates more nearly the natural position and enables compression of the abdomen against the thighs to aid in expulsive effort.

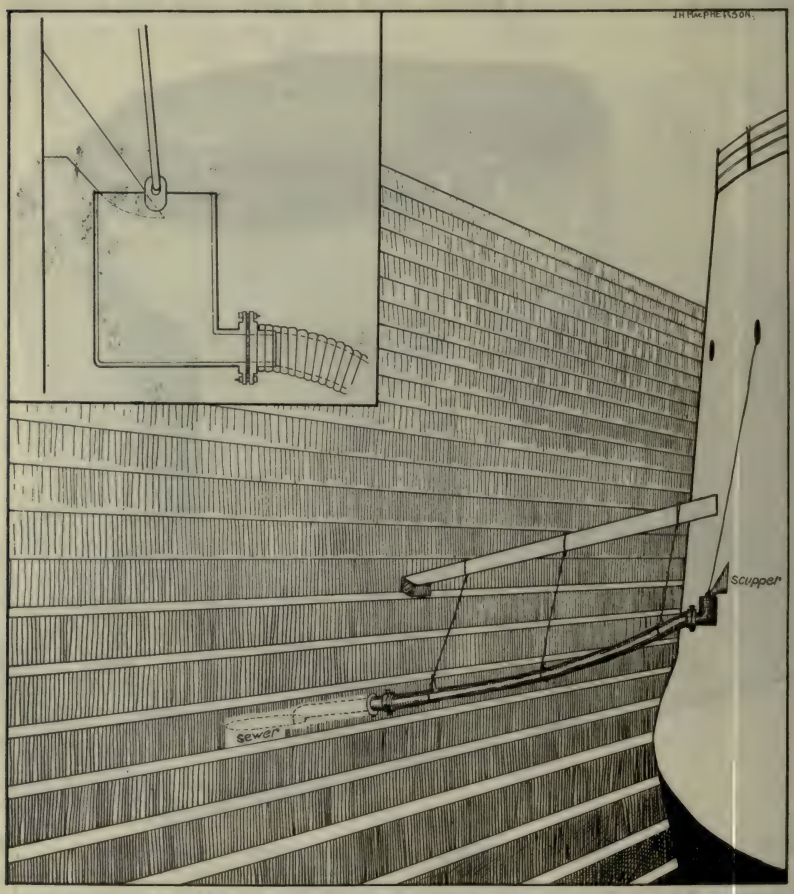


FIG. 81.—Scupper connected with sewer as the ship lies in dry dock.

Constipation is very prevalent among seafaring population, and one of the factors is believed to be the inhibiting effect resulting from muscle effort expended in balancing on a too high toilet seat, when the ship is having a good deal of motion.

In small craft whose water closets are on or below the water level a water closet of the pump variety must be employed. These closets are difficult to keep in order. The Hermes sewage ejector serves a purpose somewhat similar to that of the pump closet. Sewage accumulates in a tank which communicates by means of a valve with the outside of the ship, and at given times is expelled by an automatic application of steam pressure.

A crew of 1200 men will excrete 600 pounds of feces and nearly 4000 pounds of urine daily. The disposal of this and other sewage becomes a problem when ships are in dry dock.

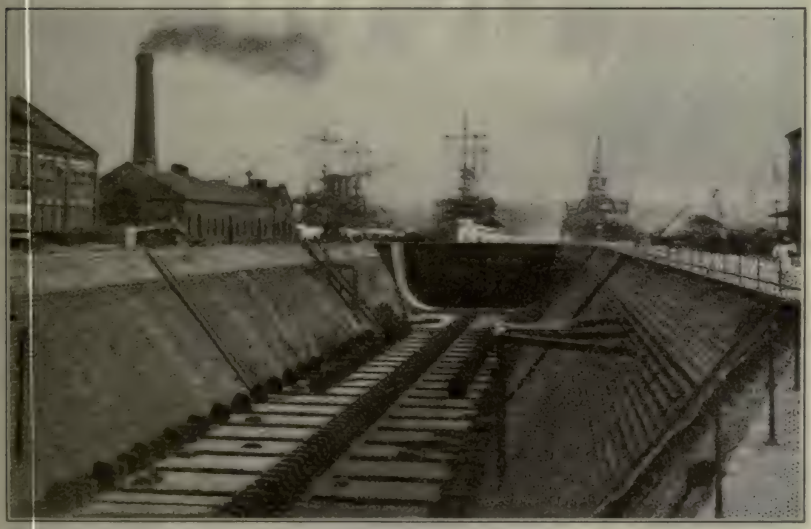


FIG. 82.—A man-of-war ready to enter a drydock.

In some dry docks connection with sewer mains are impossible. To permit the sewage from the ship to discharge into the dry dock would be insanitary. If connection cannot be made with a sewer the water closets and baths on the ship must be closed and officers and men must avail themselves of water-closet facilities to be found near the dry dock. This is uncomfortable, especially during inclement weather.

In the best-equipped dry docks arrangements are made whereby the ship's waste pipes may be connected directly with sewer mains running alongside the dock. This connection enables the use of the

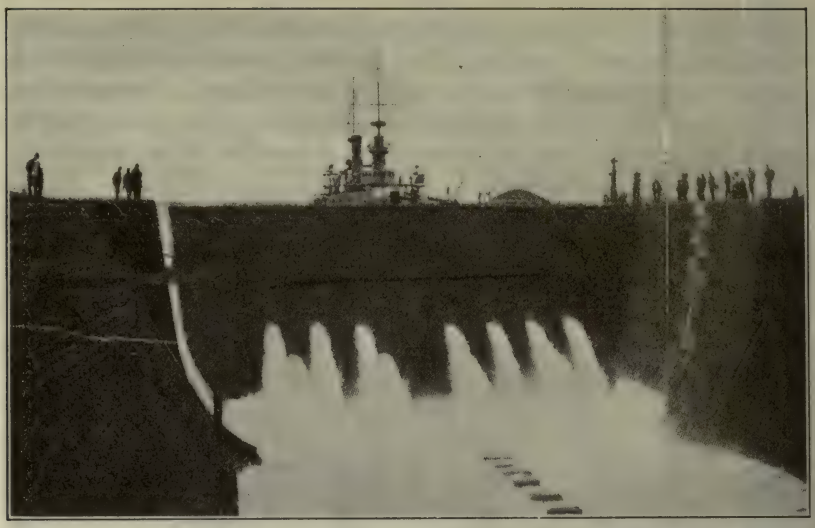


FIG. 83.—Flooding the drydock preliminary to floating in a big ship.

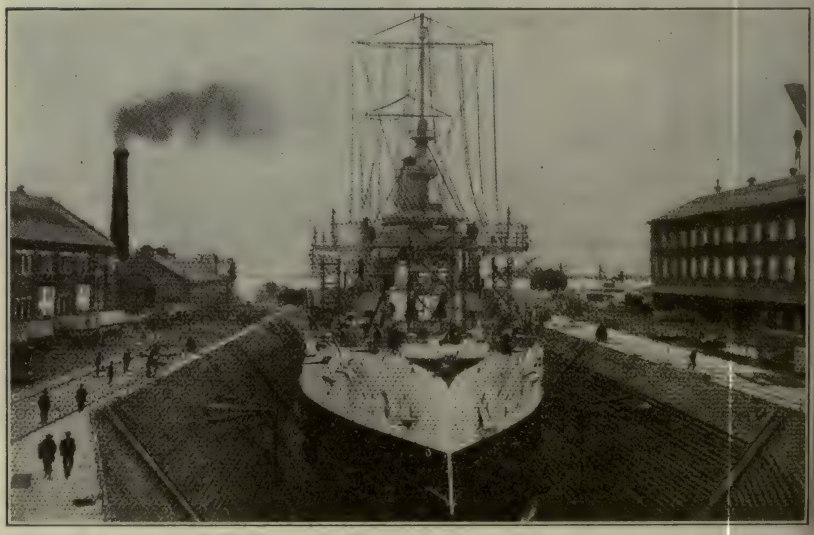


FIG. 84.—A man-of-war in the drydock. The dock has been pumped dry, the vessel has settled on the keel blocks and is shored on each side by heavy timbers which support her on an even keel.

water closets and contributes greatly to the comfort of those who must remain on board ship while she is in dry dock. (Fig. 1.)

Under Repair.—Ships undergoing prolonged repairs at Navy Yards are not fit for human habitation.

The filth incident upon the repair work; the invasion by a horde of workmen, many of whom are filthy of habit and spit anywhere; the cluttering of the ship with materials for repair; the noise of the chipping hammer; the odor of fresh paint; the noise made by the operation of pneumatic tools, improper heating in winter; difficult garbage disposal; and often the necessity for visiting a water closet on the dock in all kinds of weather day and night when sewer connections cannot be made are some of the discomforts. Barracks should be provided at Navy Yards to which the crews of ships undergoing repairs may be transferred. Here the men could live in sanitary and comfortable surroundings until the repair work is completed, leaving only enough men on board to guard and police the ship.

Garbage Disposal.—Considerable garbage and refuse accumulates on board ship as the result of the activities of its personnel.

At sea some of the refuse may be dumped overboard through the slop chute.

In time of war this cannot be done because of the possibility that it may give an enemy the clue to the ship's whereabouts. Tin cans must have their bottoms perforated, so they will sink immediately if thrown overboard, and the wood from boxes and crates must be burned.

A refuse and garbage incinerator should be installed on every big ship. The dry refuse, *e.g.*, boxes, paper, etc., may be used for the drying and burning of that which is wet. The incinerator should be connected with the ship's smoke pipe in order that odors, gases, and smoke may be conducted away from the decks.

But for the fouling of harbors and the possibility of giving information to an enemy during war the problem of conservancy would be a simple one, readily soluble by the simple expedient of dumping everything overboard.

During prolonged overhaul a ship may lie alongside a dock for some time, and in the absence of an effective incinerator the garbage must be disposed of by contract as is done in our cities.

While the garbage is being collected between the calls of the garbage wagons it should be placed in covered galvanized iron garbage cans

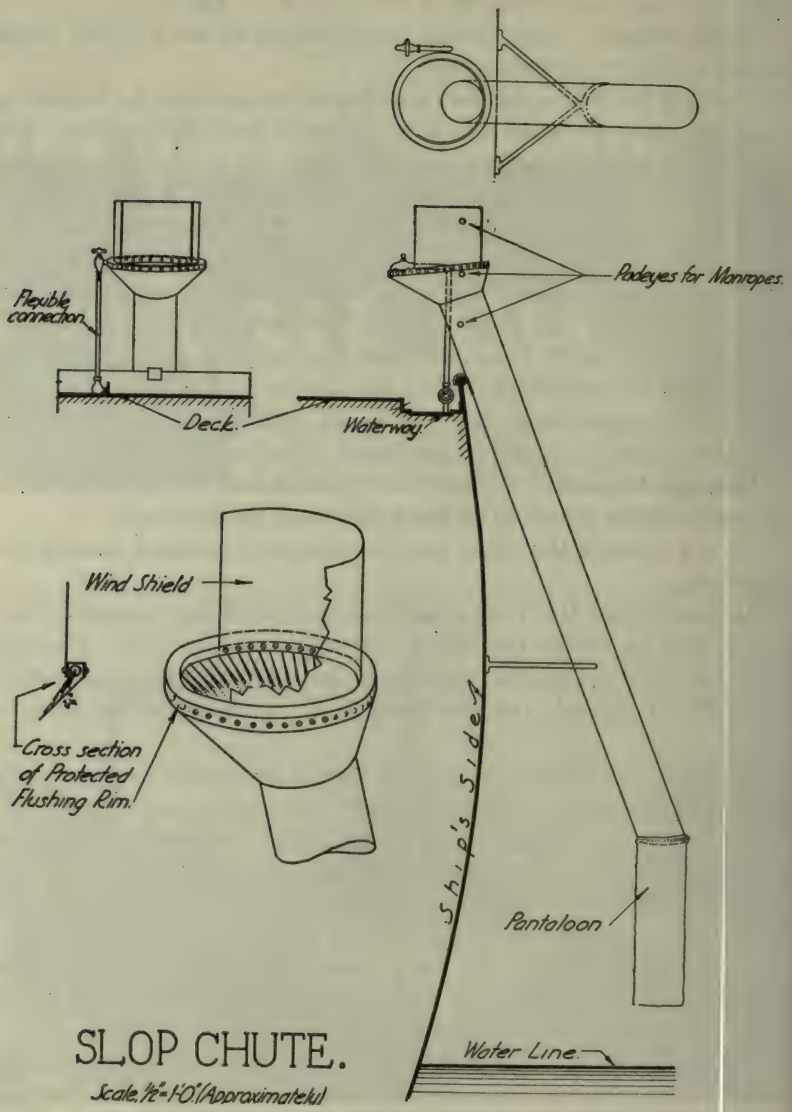


FIG. 85.—Bell's flushing garbage chute for use aboard ship.

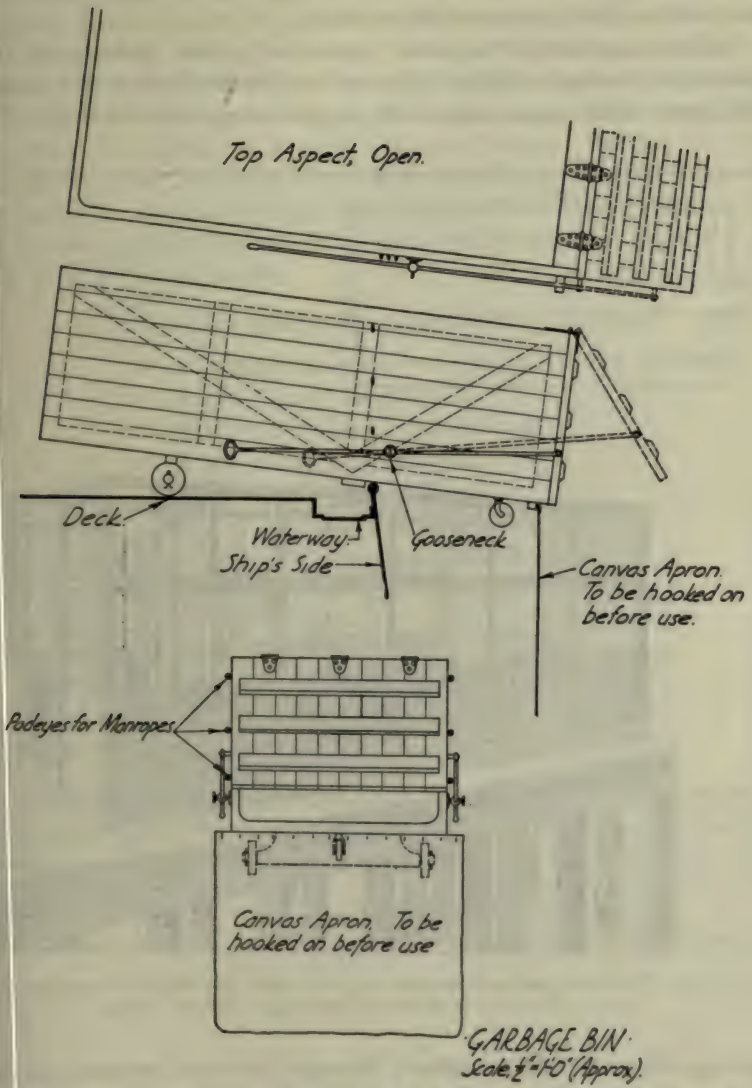


FIG. 86.—Bell's garbage bin made of tongued and grooved lumber, lined with tin, and on wheels. Designed to hold a 24-hour accumulation of garbage until arrival of a garbage lighter. For use in harbors.

having four perforations in the bottom of each to enable the draining away of the fluid portion of the garbage.

These cans should be placed inside a fly-proof garbage bin constructed of lumber sufficiently strong to withstand wind and covered preferably with copper wire cloth, sixteen strands to the inch. This

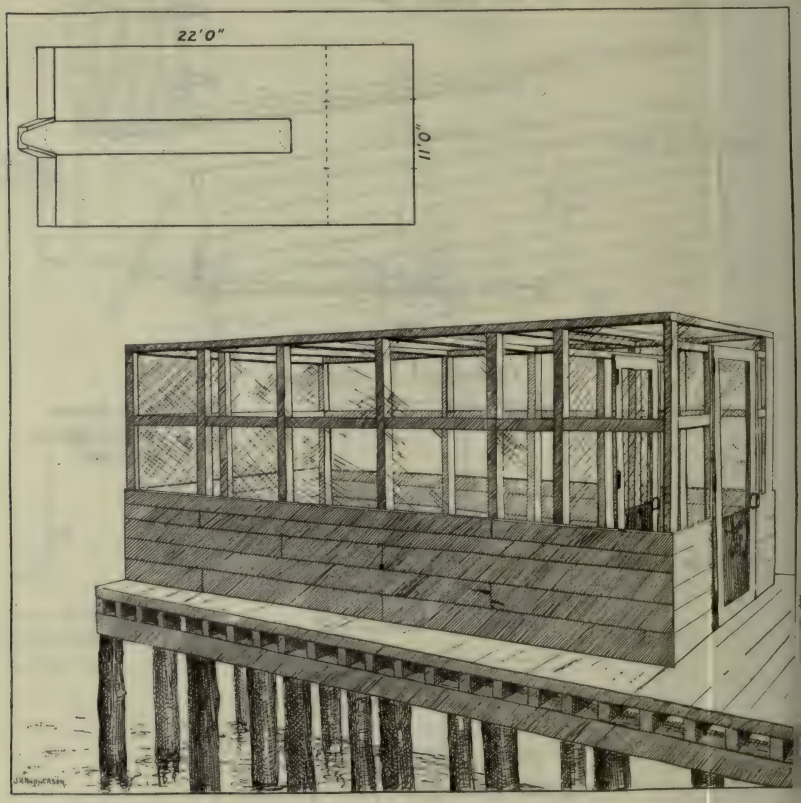


FIG. 87.—Fly-proof garbage receiver for use when the ship is alongside the dock. The drain is shown in the upper left hand corner.

garbage house should be entered through two doors between which interposed a vestibule 6 feet long, thus enabling the entrance to th bin without direct communication with the exterior. For durabilit the lower part of the walls should be made of wood to a height of feet above the floor surface. It should be fly-proof. The wire clot

should cover the remainder of the walls and roof. A shallow gently pitched groove should be placed in the concrete floor to drain away the fluid portion of the garbage as it drips from the perforated cans. This groove should terminate in a lip which extends over the edge of the dock, thereby enabling direct drainage into the harbor. This fly-proof bin should be located close to a hydrant, so that the floor of the bin may be flushed down daily and the garbage cans may be washed after the garbage has been collected from them. The above-described fly-proof bin was found most satisfactory by the writer on the U. S. S. North Dakota.

Bill of Materials for Fly-proof Garbage Receiver

216	sq. ft. tongneu and grooved pine sheathing (dressed)
20	2″ × 4″ – 6′10″ long (studs)
4	2″ × 4″ – 22′0″ long (plate and sill)
2	2″ × 4″ – 11′0″ long (plate and sill)
5	2″ × 4″ – 11′0″ long (ceiling joints)
12	2″ × 4″ – 3′5″ long (intermediate rails)
4	2″ × 4″ – 3′9″ long (intermediate rails)
3	2″ × 4″ – 3′4″ long (intermediate rails)
530	sq. ft. wire screening
2	screen doors, 2′6″ × 6′10″
32′4″	of screen door stop ½″ × 2″
121	cu. ft. of concrete, 1–2–4 mixture

Size of enclosure—11′0″ × 22′0″

On small craft the disposal of garbage is not so easy. Moist garbage cannot be burned in the fire room because it has been found to burn poorly, with the result that it tends to bank if not extinguish the fires.

CHAPTER XV

FACILITIES FOR CARE OF THE SICK ON BOARD SHIP

The Sick Bay is the Ship's Hospital.—The office of the medical officer should contain a large desk for clerical work; a sink with knee control and hot and cold water; a locker for microscope, incubator, and bacteriological outfit; and should be conveniently arranged so that sick call may be held in this office rather than in the sick bay, where patients would be annoyed by the noise and bustle incident upon sick call. This office likewise should be large enough so that anti-typhoid prophylaxis may be administered and vaccinations and examinations for enlistment, discharge and transfer may take place.

The Dispensary.—The dispensary should have appropriate shelves, bottle racks and drawers for holding medicines and dressings in a convenient manner. Desks should be provided at which clerical work may be performed, and the dispensary should contain a bunk for the chief pharmacist's mate, who should be available at all times in case of emergency.

The Ward.—The sick bay on a battleship should occupy a position on the second deck, so that it will be easily accessible from the main deck; should be sufficiently above water to permit air-ports to remain open a maximum of time, and should be so far as possible removed from the noise incident upon the anchor engine and hawse pipe forward, and from the engine room aft. If practicable it is desirable that the sick bay should extend the full breadth of the ship in order that a maximum of natural ventilation may be attained.

The *bunk facilities* should be provided in proportion of about 2½ per cent. of the complement. In emergency this will be found wholly inadequate, but in normal circumstances it will be sufficient. The bunks should be of the double-deck type which may be swung up when not occupied.

Lighting.—All electric lights should be covered with opal glass fixtures or other method of indirect illumination, so that the bare filaments may not be exposed to the eyes of those in bed. Lights

should be conveniently placed so that those occupying bunks may read or may be examined as necessity may require.

The *deck* should be covered with battle-ship linoleum and should be pitched so as to drain in case the deck is flooded. The interior of the sick bay should be painted greenish yellow, barely off white, as this

FIG. 88.—The surgeon's office and examining room also serves as a small laboratory for chemical and bacteriological work. Note the electric incubator on the bulkhead to the left of the microscope and desk.

color is found more restful to the eyes and reduces glare. All furniture should be of steel.

Ventilation.—An air supply of 400 cubic feet per bunk should be provided with necessary change of air by means of artificial ventilating

system. Artificial ventilation should take place by means of supply and exhaust systems combined, and so operating as to make a slight excess pressure in the sick bay. The louvers should be so located as to secure thorough distribution of the air supplied. Commonly the ventilation and heating are combined in the thermo-heating system

FIG. 89.—The dispensary is fitted with bottle racks holding individual bottles to prevent breakage in heavy weather. The drawers and cabinets are made of steel.

which supplies hot air. This system is not satisfactory. The vital quality or "freshness" of the air is lost by parching before it is delivered to patients. The sick bay should be heated by high-pressure steam-heating system, independent of the ventilating system.

Steel lockers having perforated doors for purpose of ventilation

and inspection should be provided for the storing of the clothing and effects of patients. Suitable racks or closets should be provided for stretchers and a closet or locker for stowing cleaning gear is necessary. A dressing table which may be swung up when not in use is very useful. This table should be located near the wash basins where hot and cold running water should be supplied, and where a large sink also should be installed. (Fig. 95.)

FIG. 90.—The sick-bay. Note the double-deck folding cots.

A steel locker for hospital furniture and surgical appliances should be provided as should a drug and poison locker.

Bathroom.—The bathroom should be painted white inside, well lighted, thoroughly ventilated by an exhaust louver and have a deck of ceramic tiling pitched to a drain in an outer corner. This room should contain one shower bath, one tub bath and two toilets. The bathtub should be porcelain lined and supplied with hot and cold water. The shower should be supplied with an instantaneous heater which should be carefully supervised to prevent the scalding of patients who

do not understand its manipulation. The shower bath should be used whenever it is practicable, but there are circumstances when the tub bath is indispensable, for instance in the treatment of cramps in men from the fire room.

A *waste sink* should be placed in the bathroom also. This should be porcelain lined. The toilet seats should be of hard wood painted with white enamel paint in order that they may be thoroughly cleaned and disinfected, and the basins should be of porcelain.

FIG. 91.—The operating room. Furniture is made fast to the deck.

The Operating Room.—The operating room on board a battleship, while compact in arrangement, may be as complete as the large rooms on shore.

The *deck* should be of ceramic tiling, pitched to drain. The room should be painted white throughout. The ventilating system should be the supply system, and the louver should not deliver air over the operating table. The electric lighting should be on two circuits so that if one fuse should blow or accident should happen during an operation the second circuit may be available.

The operating table should be of approved type of stationary table, having glass surface and appropriate drainage. The framework of the table should be painted with white enamel paint. Dressing sterilizers, instrument sterilizers, utensil sterilizers and sterilizers for hot and cold water should be provided. Electrically heated sterilizers are being used.

FIG. 92.—The isolation ward. Wash basin, water supply, and toilet enable complete isolation of an infectious case.

The racks for basins, dressing drums, irrigating bottles, ligatures and sutures should be made of white enamel and anchored so that they may not get adrift in a seaway. Stationary wash basins should be provided with hot and cold water and should have foot or knee control. The waste sink should be similarly supplied. The operating room should be made as nearly dust proof as possible and the air supplied should be filtered.

Isolation Ward.—The isolation ward should contain at least four bunks, double-banked; should have ceramic tiled floor; should be lighted and heated just as the main sick bay, and should be ventilated by a

separate supply and exhaust. It should have an air space of 800 cubic feet per capita. The isolation ward on board ship should be supplied with a separate water closet, otherwise complete isolation of infectious diseases is impracticable, as was seen on the U. S. S. Ohio during the small-pox outbreak some years ago.

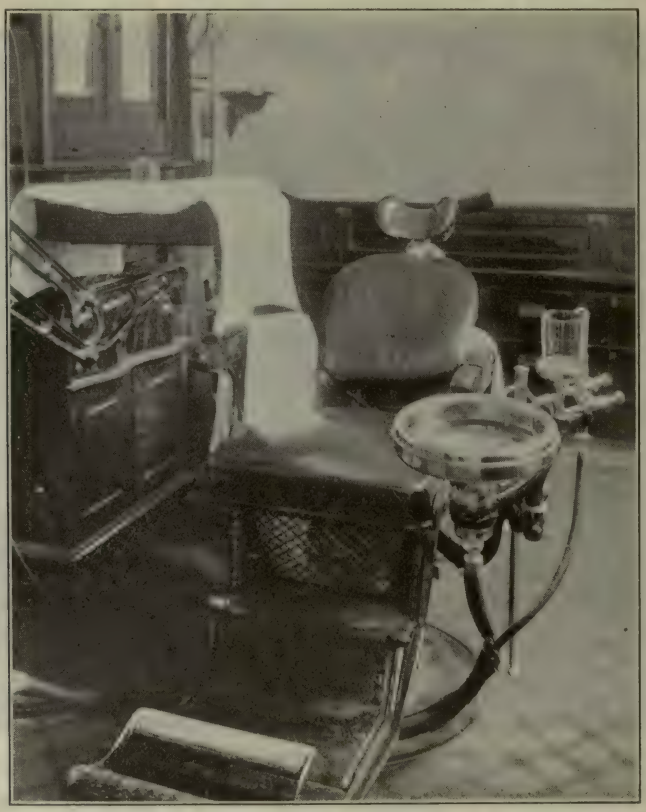


FIG. 93.—The dentist's office is well equipped with modern apparatus and instruments.

A room should be installed for venereal and prophylactic treatments.

An **office for the dentist** containing a dental chair, equipment, instrument cabinet, hot and cold running water with knee or foot control, and desk for clerical work, should be supplied.

Storeroom.—The medical storeroom should be located in the hold of the ship and should be as cool as practicable. Certain drugs dete-

riorate rapidly when exposed to heat. It is a common experience to find ampules of amyl nitrite have exploded in their original wrappers in the storeroom.

The storeroom should be well lighted and ventilated. It should be as nearly dust proof as possible for the protection of surgical dressings and hospital equipment.

The bulkheads and all shelves should be painted white. White paint aids the inspecting officer. Dirt on it is easy to see. The shelves should be of sheet metal as protection against fire.

Battle Dressing Stations.—Battle dressing stations on board battleships should be located fore and aft behind the armor belt. In action it becomes necessary to evacuate the sick bay and place the activities

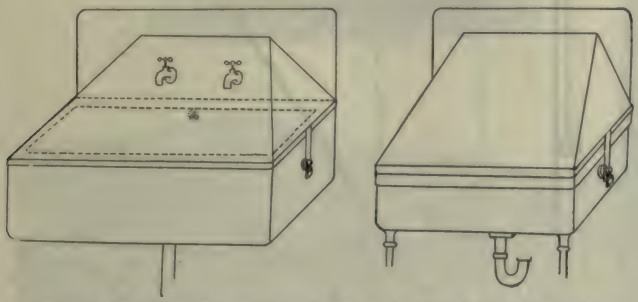


FIG. 94.—Covered sink and wash basin in a battle dressing station. Locked metal covers prevent unauthorized use of these fixtures.

of the medical department in a less exposed position. Each battle dressing station should be provided with hot and cold running water, led to wash basins and a waste sink.

Steel lockers for emergency surgical dressings should be provided, and if practicable the medical storeroom should be close to and easily accessible from the main dressing station. The waste from the battle dressing stations should communicate with the ship's drainage. Abundant light should be provided for all portions of each battle dressing station, and it should be on two circuits from different sources if possible.

There should be supplied sufficient light, with a reflector, to enable the performance of necessary surgical work. A large gravity tank should supply the necessary water. This tank should be behind armor and should be filled before going into battle. A sanitary scuttle butt should be installed.

It should be remembered that in time of stress facilities for the disposal of excreta will be needed and should be provided in the shape of pump closets, possibly communicating with the ash ejector.

Steel tables which may be swung up when not in use should be placed on the bulkheads near to the side selected for the operating table. These may be utilized for dressing tables or tables for basins.

Sufficient number of clean, new swabs should be kept in the dressing station lockers for emergency use, and stretchers likewise should be

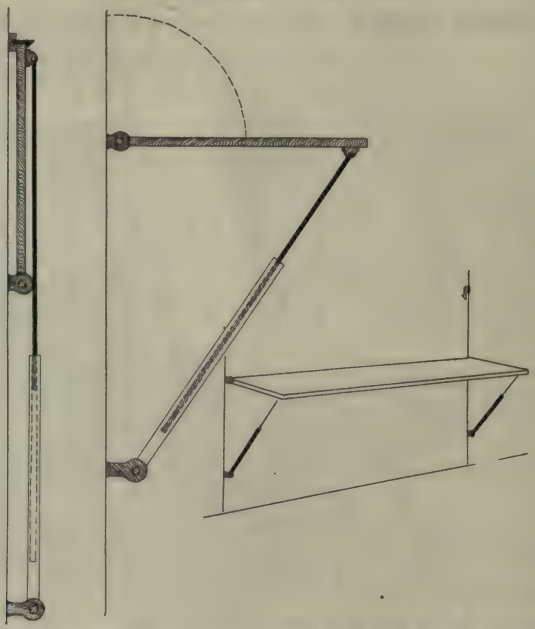


FIG. 95.—Folding table. When not in use it is folded back against the bulkhead. A useful dressing table.

provided. Connections for electrical sterilizers and electrical heaters for preparing special diets likewise should be installed.

The surgical equipment from the main operating room should be moved to the principal dressing station, and a portable operating table may be supplied for the second battle dressing station.

Preliminary to going in action sterile solutions of morphia should be made up in quantity, and placed in vials covered with sterile rubber dam, through which a sterile needle of a hypodermic syringe quickly

FIG. 96.—The Stokes splint stretcher, transferring a man from a ship to a small boat.

may be thrust to charge the syringe after the dam has been wiped off with gauze or cotton saturated with alcohol.

The question of air supply in battle dressing stations is a difficult one in time of action as probably the blowers will be shut down, and it will be necessary to depend upon such air as may be in the station at the time of engagement.

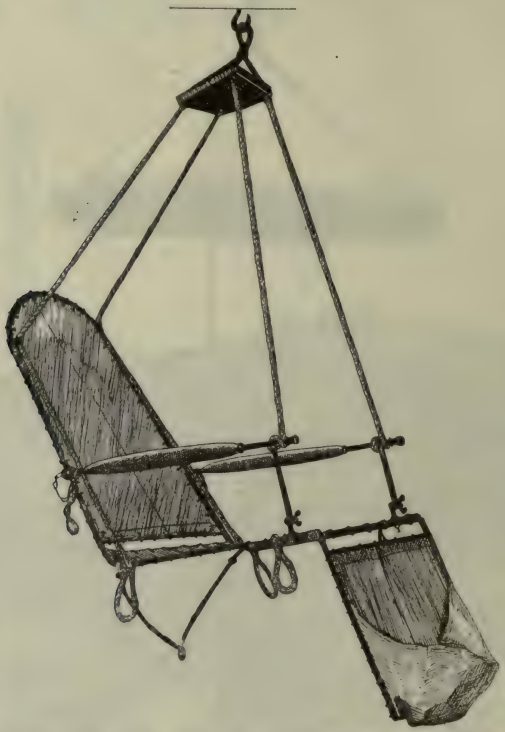


FIG. 97.—The stretcher chair used for transporting wounded in the German navy.

Transportation of Sick and Injured on Board Ship.—There are many locations on board ship in which sick or injured men must be **man handled** because of their inaccessibility. This **handling** should be carefully done in such way as not to aggravate the injury. The pack saddle is a very effective way of carrying the conscious patient who may be able to give some assistance by clinging around the necks of his

bearers. Where only one person is available the problem is much complicated. Help should be sought as it is dangerous for one man to attempt to carry an unconscious man through the narrow passages or up the ladders. Carrying by hand is the most generally useful method aboard ship.

Of the **mechanical appliances** used for the transportation of sick or wounded the Stokes Splint Stretcher is most commonly used on

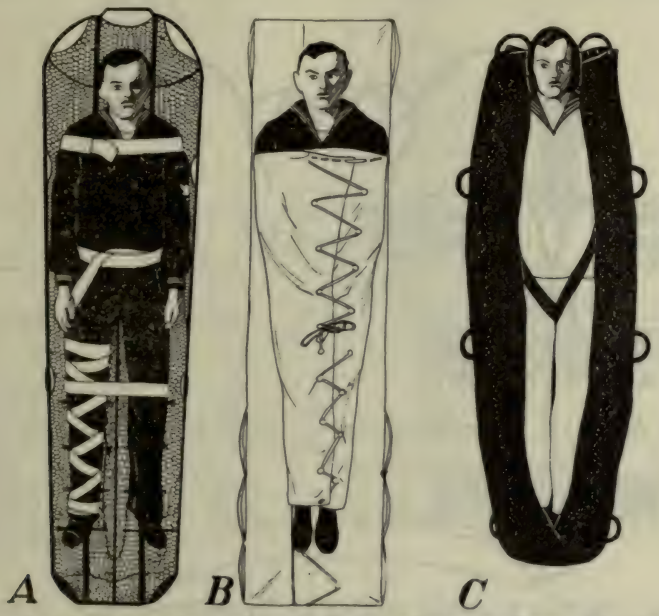


FIG. 98.—*A*. A man strapped in the Stokes splint stretcher used in the United States Navy. *B*. the Lung apron stretcher. *C*, the hammock stretcher used in the German Navy.

board ships of the U. S. Navy. It is a galvanized iron stretcher-basket which has certain fixation apparatus attached to it. These consist in straps which pass over the patient's chest, hips and legs as he lies in the wire basket. A movable foot rest is provided on each side of the septum which divides the lower end of the basket into two big furrows for the legs of the patient. An opening is provided in case it becomes necessary to permit the stretcher patient to use the bedpan. There are hand grips around the strong galvanized iron frame which forms the

upper margin of the basket. These may be used either for carrying the stretcher by hand, or for attaching it by means of a bridle to a hoisting apparatus for lowering to or hoisting from a small boat. This splint stretcher is very useful in getting men out of small spaces, as when the patient has been strapped in the stretcher, and patient may be hoisted to a vertical position and raised perpendicularly. This stretcher is not intended for field use as it is too heavy and too expensive for such purpose. It is without equal for the transportation of patient

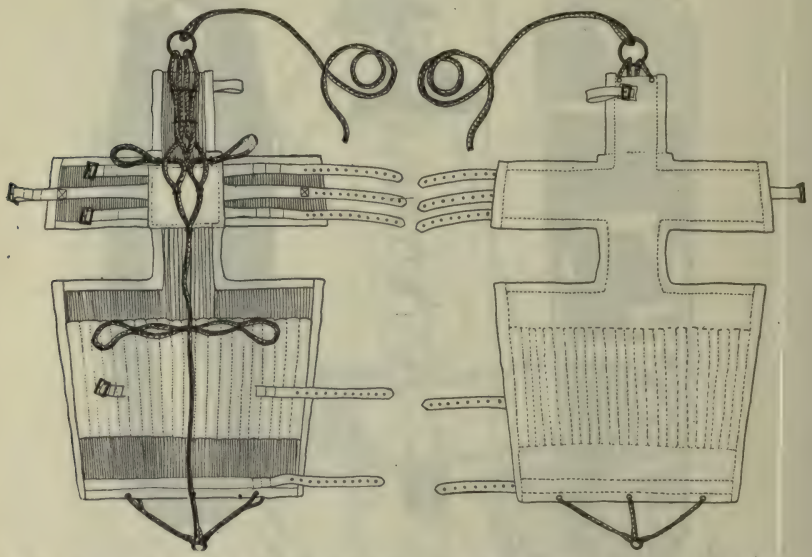


FIG. 99.—The Neill Robertson stretcher used in the British Navy. It is made of canvas and bamboo strips and may be swung as a hammock.

from ship to hospital or for shipment by rail of patients having fractures. It possesses the further advantage of being non-inflammable and easily disinfected.

The light **canvas litter** used by the U. S. Army is used also by the medical department of the Navy, but it generally accompanies landing forces, as it is lighter than the Stokes stretcher. It is not efficient on board ship because when loaded this stretcher cannot be handled at hatches or going from one deck to another without danger of the patient's falling.

A light and serviceable *stretcher* made **of canvas, stiffened with bamboo** and having beckets with which it may be carried, or may be

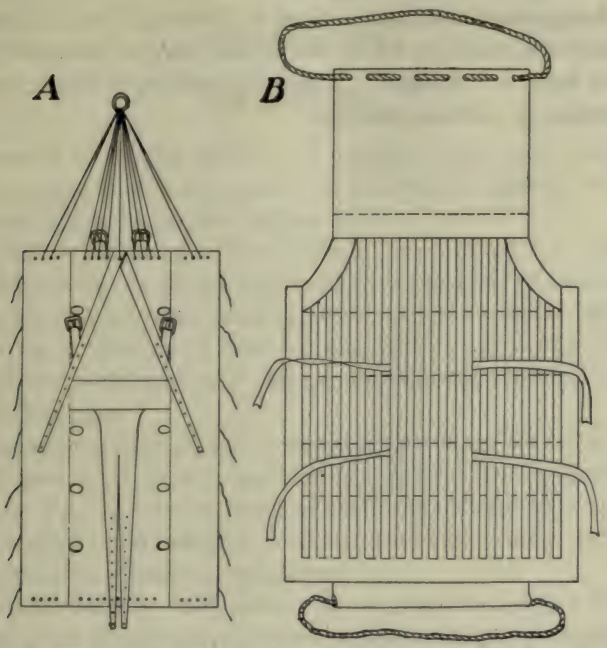


FIG. 100.—*A*, The stretcher hammock. (*Guezennec.*) *B*, the Totsuka stretcher used in the Japanese Navy. (*Surgeon-General Braisted's Report.*)

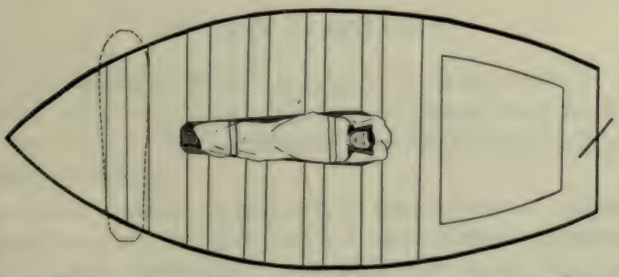


FIG. 101.—Patient properly placed in stretcher on a small boat. The dotted outline indicates an incorrect position from which the stretcher may be pushed as the boat comes alongside a float, ship, or landing.

suspended vertically when the patient is strapped in it is in use in the British Navy. This is known as the Neill Robertson stretcher and

is similar to the Totsuka stretcher used by the Japanese. The Germans employ a **canvas hammock stretcher** into which the men may be strapped and carried by beckets.

The **Lung apron stretcher** devised by Medical Director Lung, U. S. N., consists of a board to which the patient may be strapped by means of canvas flaps or "aprons." There are beckets to enable its carrying or suspension in vertical position.

CHAPTER XVI

RECRUITING

The careful recruiting officer is a "watch-dog of the Treasury." Upon his acumen in the recognition of deformity, disease, or vicious habit depend potential pension claims.

None but experienced officers should be detailed for recruiting duty. A knowledge of service requirements is necessary to enable nice discrimination in border-line cases in which acceptance of the individual may incur an obligation to care for one who is physically unfit, or rejection of the individual may lose for the country the services of an efficient, willing man.

This experience likewise will enable the recruiting officer to decide whether a man is physically qualified for performance of duties of a given rating: *e.g.*, X may be small of stature and light in weight and yet make a good radio operator, while he would be utterly unfit to do the heavy work required of a coal-passer.

A moderate myopia may almost be an asset to a ship's writer, or yeoman, and yet totally disqualify a candidate for gun pointing.

The candidate should be clean and sober at the time of examination.

System of Examination

Unless the examiner adopts a system of examination he may be chagrined by being asked to explain why he passed candidates having disqualifying defects. Some system of examination should be adopted and adhered to rigidly.

I have found it most satisfactory to take **a cursory general view of the candidate** and then commence **a careful physical examination,** taking head, upper extremities, chest, abdomen, inguinal and perineal regions, and lower extremities **in the order named.**

Following this the **motion of the principal joints** of the body is carefully studied. The **measurements then are taken and the records made.**

Cursory General View.—In the cursory general view of the stripped candidate disqualifying defects such as lordosis, ankylosis, large hernia, etc., may be evident at once. Marked stigmata of degeneration should be noted and any personal peculiarities or deformities tending to make their owner a butt of ridicule by his fellows should cause rejection.

The presence of obscene devices tattooed on the skin strongly suggests a sexual pervert. Burn scars may indicate an epileptic.

Pulmonary tuberculosis or other grave constitutional conditions as well as possible drug addictions may suggest themselves in this examination. Skin diseases and pediculosis will be evident.

During this examination the medical officer should observe as far as possible the quality of mind possessed by the applicant, judging from the character of his replies and the intelligence with which he executes the instructions given to him in the course of the examination.

The tendency of the candidate desiring to enlist will be to minimize physical defects, which subsequently may be exaggerated greatly in the desire to obtain discharge from service because of alleged disability.

The examiner invariably should question the candidate as to whether he has recently suffered from:

(*a*) Fits (epileptic attacks, etc.);
(*b*) Nocturnal enuresis; or
(*c*) Concealed disease of any character.

The preparation of the descriptive list should be made not as the examiner progresses, but at the completion of the examination when his entire attention may be directed to this important feature of the work.

Examination of the Head.—The *head* should be examined carefully for lice or any infectious disease of the skin, for marked cranial asymmetry, scars or depressions which might suggest previous skull injury, and possible cerebral irritation. At this time also the glands in the cervical triangles, anterior and posterior, should be examined.

The *Eyes.*—Absence of eyebrows and cilia should be noted as suggestive of syphilitic infection. The lids should be examined for evidence of disease and any purulent discharge in the conjunctival sac should lead to careful examination of the lacrimal sac. Marked strabismus should cause rejection. The cornea should be examined for opacities and the iris should be clear of synechiæ. It should respond normally to light.

The functional examination of the eye consists in:

(*a*) Determination of color perception;
(*b*) Determination of visual acuity;
(*c*) Special examination of applicants for aviation duty (see page 267).

(*a*) **Determination of color perception** should be carefully carried out. It should be remembered that limited color perception may be tolerated in certain ratings, but in most ratings in the navy the color perception should be keen. Perhaps in no rank or rating in the service should the requirements in respect of color perception be more rigid than in the members of the medical corps who must themselves examine others. More than 2 per cent. of all applicants for the naval service were rejected during 1917 because of color blindness.

The Holmgren method is that which is prescribed by Navy Regulations. While perhaps this method is best adapted for all-round use in the naval service, the Jennings method, the Edridge-Green Lamp and the Thompson Lamp have their advantages and disadvantages.

Functional Examination.—(*a*) *Holmgren Method.*—In this method the three large test skeins are shown to the candidate in a definite order, viz., light green, rose pink, and red. *It is of utmost importance that this sequence be observed invariably.*

The large, light yellowish-green skein is first shown and the candidate is required to place beside it those of the same color (but not necessarily of the same shade) from the pile of various colored skeins. This test alone determines whether the candidate is red or green blind. Those possessing feeble chromatic sense will hesitate while normal color perception will enable the candidate to select the skeins promptly.

The color blind will select wrong colors of about the same shade. He may put a light blue, light purple, light green, light red, or even a light gray all in the same pile in attempting to select greens to go with the green test skein. If he selects only greens his color perception is normal. If with the green he selects other colors *he is "color blind."*

He now should be shown the rose-pink skein. If he selects skeins of the same color his color perception is normal. His performance with the green skeins is corroborated. But if he has been shown to be "color blind" by the green test he will:

1. Select green or gray and place it with the rose-pink test skein; or
2. Will place only purple with it.

In the first case he is completely red-green blind; in the second he is partially "color blind."

The red test skein should now be shown to the candidate. If he selects the shades of red and places them with it he merely corroborates the evidence of normal color sense shown in handling the green and rose-pink test skeins.

If, however, he has been shown color blind by the two tests just described he will make characteristic blunders, viz., selection of dark greens if red blind and selection of light greens if green blind.

In making this test the *names* of the colors should not be mentioned. Many persons are color ignorant. They should be required to "select skeins of the same color, light or dark," independently of their names. This gives the test of their color perception.

Color ignorance is as important as color blindness from a practical viewpoint. Consequently after the examination of color perception is completed the *names* of the several primary colors invariably should be asked.

The lookout who misnames colors is almost as dangerous as the man who cannot see them. Where a large number of men are to be examined time will be saved by permitting them to observe the examination of a candidate. They will then understand what is desired and will go through the test much more rapidly than if instructed individually.

It is a good plan for the examiner to go through the test, showing just what is required. Such procedure will give little or no aid to the color blind who will blunder hopelessly despite the demonstration.

The skeins should be clean and should be kept from the light when not actually in use. They fade and get full of dust.

(*b*) *The Test for Visual Acuity.*—The Grow Unlearnable Card or the Snellen test card is used, the former being better adapted to service needs despite the slight disadvantage that the patient with poor vision must approach nearer than the standard test distance set by Snellen, viz. 20 feet.

The candidate should be required to look *directly* at the exposed letters with his uncovered eye. The covered eye should be completely occluded by some opaque blinder which will fit snugly in front of the eye and permit no vision in the covered eye. The distance from the card to the candidate should be 20 feet. The light should be good.

The vision of the would-be gun pointers should be tested *out on deck in the open*, under conditions which have to be met in target practice.

Normal vision is not necessary in certain ratings, but is desirable in all. The vision of the store-keeper need not be so acute as that of the gun pointer. $V = 20/20$ *B. E.* is required for the gun pointer, whereas $V = 15/20$ *B. E.* may be accepted in certain other ratings.

The Nose.—Deviated or perforated septum, hypertrophied turbinates, ozæna, occlusion of one nostril, and adenoids should be in mind during the examination. If the candidate closes one nostril and inspires forcibly through the other valuable information may be obtained.

The Mouth.—The examiner should look for deformities, or scarring from disease (syphilis). Mucous patches, tuberculous ulcers, Vincent's angina, tumors, or deformities should be evident. Hypertrophied or diseased tonsils should lead the examiner to inquire closely for history of rheumatism, or of diphtheria. The possibility of the candidate being a "carrier" should be in mind.

It is most important that the recruit have at least twenty sound teeth. Of these there must be four molars and four incisors which oppose.

The Ears.—The ears should not be deformed and should have a normal auditory acuity of 15/15 in each ear for the spoken voice, and 40/40 for the watch. Complete deafness in one ear is cause for rejection. The examiner should *see* the membrana tympani, if it is present, and note any abnormality about it.

In testing with the spoken voice the examiner of experience stands 15 feet from the candidate and whispers in a low tone or stage whisper certain phrases, names or numbers, and asks the candidate to repeat same, indicating that he has or has not heard.

When several persons are to be examined it may be found convenient to have them stand facing one direction on a line at right angle to that upon which the examiner stands facing them. Having the opposite ears closed they listen with the ears exposed to the examiner. The surgeon should require one man to repeat the phrases and the others to indicate by raising their hands whether they have heard. Each man in turn should be required to repeat the words, the others indicating by hand that they have heard.

The examiner should be on the alert to discover perforation in the tympanic membrane or evidences of inflammation.

In testing for auditory acuity he should require the candidate to keep his mouth closed during the test. The ear opposite to that being tested should be thoroughly closed by a folded towel held by an assistant.

The Neck.—The neck should be examined for glandular disease (including goiter) and for deformities, congenital or acquired.

The Arms and Hands.—The arms and hands should show no loss or deformity of any part. Ankylosis of a joint may be immediately evident, but may not be recognized until the systematic examination of joints which will take place later. The stained forefinger of the cigarette smoker should attract special attention to the heart. The epitrochlear glands should be palpated for sign of enlargement.

The Chest.—The examiner's keenest powers of observation will be taxed to the utmost in examination of the chest. Deformities such as pigeon breast should be noted. Auscultation upon which so much depends often may be next to impossible. None who has not actually had the experience can realize the impossibility of making a careful physical examination aboard ship while pneumatic tools and chipping hammers are making their infernal clatter upon resonant steel plates nearby. The examiner should remember that the hard rubber diaphragm on some of the stethoscopes in the market may give sounds simulating diseased conditions.

The Lungs.—Departures from the normal vesicular murmur of healthy lung tissue should be regarded seriously. Repeatedly young candidates who have had a tuberculous history have been told to "take a sea voyage" and present themselves for enlistment. History should be carefully considered.

If tuberculosis is suspected, reject. Too much is at stake. A tuberculous individual is in too intimate contact with others aboard ship to warrant running risk.

In each case the examiner should satisfy himself of the presence of normal expansion of lung tissue, posteriorly and downward.

The Heart.—Examination of the heart should be conducted carefully and in accordance with usual methods. Marked enlargement or displacement of the apex beat should be carefully considered and usually the candidate should be rejected.

It is believed that hæmic, cardio-respiratory murmurs and pseudo-murmurs caused by the faulty use of the stethoscope have resulted

in rejection of individuals having sound hearts more frequently than commonly is realized.

The examiner cannot too quickly reject an applicant because of an organic murmur, but he should assure himself of probable organic origin before rejecting.

Tachycardia is very common among young adult cigarette smokers, but the examiner should remember it is one of the early signs of pulmonary tuberculosis, or may indicate an exophthalmic goiter. Opportunity should be given for the candidate to recover from overexertion or from excitement. If, then, the pulse rate exceeds 100, reject.

The Abdomen.—The examiner should examine liver, spleen, appendix, and kidney regions for evidence of disease. The umbilicus should show no hernia. The applicant should be questioned carefully for history of abdominal disease.

Inguinal Region and Perineum.—The examiner should exclude lice and venereal disease. He should require the applicant to strip the urethra thoroughly for evidence of gonorrhœa, and the prepuce, glans, and frenum should be closely scrutinized for venereal sores or scars.

Varicocele, hydrocele, undescended testes and hernia should be detected if present.

Double varicocele should be cause for rejection. Too commonly lymph leg or scrotum results from the disturbance of vessels incident upon bilateral operation for varicocele.

Patulous inguinal rings are apt to develop into hernia under the heavy work of actual service.

The anal region should be examined for evidence of disease. An individual possessing a markedly patulous anus should be summarily rejected.

Lower Extremities.—Deformities, varicosities, flat foot, hammer toe, overriding toe, and bunions should be detected by the examiner.

Marked varicose veins should cause rejection. The deep veins are probably just as varicose as the superficial ones.

Operation is the only remedy for hammer toe. The examiner should assure himself that a depressed arch actually exists before rejecting an applicant for flat foot. Too commonly the error is made of diagnosing a well-developed plantar musculature as flat foot. Absence of either great toe is cause for rejection.

Examination of Joints.—Commencing with the temporo-maxillary articulation, the vertebral, shoulder, elbow, wrist, phalangeal, hip,

knee, ankle, tarsal and phalangeal joints should be exercised in order. Limitation of motion, ankylosis, or contracture should be noted.

Old dislocations, evidence of bone disease, or joint effusion should not escape the examiner.

The examiner now is in position to take the measurements required and to dictate for record the descriptive list of personal characteristics.

Measurements.—*The height* is taken by having the applicant stand without shoes, with his back to a vertical rod or plane, at right angle to which is lowered a ruler or moving member of a measuring apparatus. It should barely touch the scalp as the head is moved gently from one side to the other.

Chest Measurements.—A tape measure around the bare chest at the nipple line will give the measurements on inspiration and expiration. The difference between these gives the chest expansion (provided the well-recognized muscle trick of *apparently* expanding the chest is not brought into play). This should never be below 2½ inches. Measurement of the chest upon inspiration always should be considered with reference to measurements taken at the umbilicus at the same time.

Weight.—The nude applicant should be weighed upon previously balanced scales.

As result of long observation a standard of weight for height has been established (see Appendix) and experience has shown the folly of departure from these standards. The individual who is below the minimum weight for his height probably will develop pulmonary tuberculosis if the disease is not already present.

The Descriptive List.—The examiner should exercise great care in filling out the applicant's descriptive list. Color of eyes and hair should be accurately stated, and personal peculiarities should be noted. The location of moles, nevi, tattoo marks and scars should be carefully noted on the outline figure card. These with the finger prints, which are taken, give accurate data for indentification.

Vaccination.—The examination of the applicant should not be regarded as complete until he has been vaccinated and has received the initial dose of anti-typhoid prophylactic.

During 1917 the principal causes of rejection of persons examined for original enlistment in the U. S. Navy were:

	Navy	Marine Corps	Naval Reserve
Errors of refraction	5,360	1,537	20
Under weight	4,507	890	7
Defective teeth	3,935	943	3
Flat or weak feet	3,534	1,494	3
Deformities	2,822	731	7
Varicose veins or varicocele	2,331	774	3
Under height	1,623	501	...
Heart affections	1,439	863	5
Color perception defective	1,352	363	2
Genito-urinary (venereal)	914	433	2
Tuberculosis or suspects	657	252	2

CHAPTER XVII

AVIATION

Aviation has become such an important factor in military and naval operations that a brief consideration of it is warranted.

Ability to attain high altitudes is desirable in time of war for the dual purpose of avoiding anti-aircraft guns and preventing discovery of the fliers. An officer who was in London during the most disastrous air raid against that city states that owing to the altitude of the invading machines they were almost invisible, and further that the motors could be heard scarcely, if at all.

Battle planes are fighting now at an altitude of 19,000 to 20,000 feet.

Since air pressure diminishes fairly rapidly as distance above the earth's surface increases, vertical ascents must be limited to a distance of from 2½ to 3½ miles unless oxygen is used.

Kent says: "At the sea level the pressure of the air is 14.7 pounds per square inch; at ¼ mile above the sea level it is 14.02 pounds; at ½ mile it is 13.33; at ¾ mile it is 12.66; at 1 mile 12.02; at 1¼ miles 11.42; at 1½ miles 10.88; at 2 miles 9.80 per square inch."

It is a good rule to remember that pressure decreases ½ pound per square inch for each 1000 feet of vertical distance within the range normally traversed by the aviator. This rule enables rough approximation of pressure at any altitude and gives data sufficiently definite for practical purposes.

At an altitude of 18,500 feet a cubic foot of air has only half the weight of a cubic foot of air at sea level.

Hydroplanes are heavy and cannot attain the same heights reached by lighter machines built for aviation on land. The practical limit of hydroplanes today appears to be about 16,000 feet.

The aviator should be selected after a most rigorous physical examination in which especial attention is paid to his organs of equilibration. The "air feel" cannot be developed without proper function of the organs of equilibration. The aviator must be keen, alert, active,

powerful, and in full possession of vigorous strength and manhood, for he is compelled to venture into physical conditions abnormal to the average human being. Oxygen poverty of the air in high levels may interfere seriously with his performance of any muscular work, unless an oxygen supply is carried.

The Manual for the Medical Department of the U. S. Navy prescribes the following examination for candidates for aviation duty (this is in addition to the examination for physical fitness for general service).

(*a*) Normal vision (at least 20/20) in each eye will be required, and no variation below the prescribed minimum standard height or below the mean chest circumference and the prescribed expansion shall be allowed. In all such candidates a normal heart and normal lungs with full and free expansion are of prime importance. Blood pressure will be taken before and after exercise and any marked departure from normal will be cause for rejection. A urinary examination will also be made and disease so disclosed will invariably lead to rejection.

(*b*) In requiring normal acuteness of vision and hearing, medical officers are cautioned to recognize that such acuteness is merely one factor in normal functions of eyes and ears, separately and coördinately. For instance, accident in landing an airplane may be regarded as frequently due to error of judgment in regard to distance from earth at the time the machine should be "flattened out." Yet, correct judgment depends upon many factors and even simple acuity of vision can be considered as being of great importance at times in such cases. Furthermore, while judgment may depend essentially upon central conditions, it also has important relation to reflexes from eyes and ears which may dominate those conditions. Therefore, in that direction can frequently be found varying ability of central nervous systems to maintain coördination and a normal sense of equilibrium with reference to acts urgently required. Hence, full functions of eyes and ears are essential for duty in the Flying Corps, but acuity of vision and hearing is only a part of those functions. Nevertheless, good vision is very helpful in selecting a suitable landing field in forced landings and in allowing efficiency without glasses or goggles that can be pushed out of the way when obscured at any time by oil (engine-in-front type); while normal hearing has been found to give essential assistance in detecting the first signs of engine defect while in the air or in detecting such defect prior to flight.

(*c*) In considering eyes, all practicable attempts will be carefully made to seek indications of abnormality of function in any direction. In that connection reference is made to requirement of even pupils and equal and full reactions to light and distance, and also to freedom from any appearance of disease in eyes and adnexa. Strabismus or squint in any manifest degree is cause for rejection. Ocular movements, observed while having the eyes follow the finger of the examiner, must show no lack of coördination, and there must be no nystagmus on turning the eyes to right or left 40 degrees or when looking to the front.

(*d*) In relation to ears, the first consideration is acuteness of hearing which will be determined by the usual methods; but in the watch test the examiner shall use a watch he has standardized. For that purpose he shall satisfy himself as to the usual average maximum distance the watch is heard by at least five men found to have

normal drums and considered from association to have normal hearing. The determination must be made under the conditions to which candidates would be subjected in carrying out the test, and the distance in inches so determined shall be used as the denominator in computing the usual fraction for the record; but the full distance will be required for acceptance. The drum and auditory canal of each ear will then be examined with a speculum. Perforation, pus, odor, or any evident condition of disease is cause for rejection. Indication of middle-ear trouble shall be regarded as of special importance, and it should be recognized that such indication is often found in the very diminution of the sense of hearing which is regarded as a cause of rejection. A contributory cause should be sought in examination of nasal septum and for those conditions of the throat and nose suggestive of interference with patulousness of eustachian tubes, such interference not only being in association with middle-ear disturbances, but also preventing the aviator from securing the required balance of air pressure on the ear drums when ascending, or, of special importance, in more or less rapid descents.

(*e*) The practicability, or even advisability, at this time of seeking to make definite inquiry into functions of equilibrium through nystagmus induced by excitation of vestibular mechanism may be regarded as more or less in question in view of normal differences and also of variations in the personal equations of examiners. Such nystagmus may be produced by rotary, caloric, compression, or galvanic methods.

(*f*) However, in seeking abnormality in function of equilibrium there are certain valuable static and dynamic tests that must be made at each examination. In these tests the candidate is required, without shoes, and first with eyes open and then closed, to:

1. Stand with knees well back and inner margin of feet touching;
2. Stand on toes in position 1;
3. Stand flat on right foot and rest left foot on right knee or instep;
4. Stand flat on left foot and rest right foot on left knee or instep;
5. Walk forward with feet flat;
6. Walk to the right in a circle with feet flat;
7. Walk to the left in a circle with feet flat;
8. Walk backward with feet flat;
9. Hop backward on both feet flat;
10. Hop backward on right foot flat;
11. Hop backward on left foot flat.

Position 1 should be held for two minutes without abnormal swaying, and position 2 for a minute. Normal attempts at balancing have no significance. Positions 3 and 4 should be held for at least a quarter of a minute. In tests 6 and 7 there should not be expectation of candidate making mathematical circle, especially with eyes closed, but only that he will normally tend to follow the general direction of a circle. In making these tests and watching for abnormal deviations, the examiner must recognize that they have relation not only to peripheral nerve disturbances but also to central conditions, especially those of luetic origin, and that the patella, tendo Achillis, and pupillary reflexes must be considered with them. In the case of the candidate examined for transfer or detail the blood-serum test for specific disease will also be secured, and such test will be secured in other cases when practicable.

(*g*) The static and dynamic tests must also be considered in connection with the prescribed routine examination to determine the free and full movements of joints. In relation to the knee and ankle joints it is evident that their finer movements play a very important part in rudder control, especially in a fast machine requiring quick-acting controls. Difficulty in those joints may also lead to the abnormal position in an airplane that tends to cramping of muscles.

(*h*) In the consideration of a suitable type of individual the anemic should be discarded, and also the asthmatic, emphysematous, or obese. The desire is for the active with freedom from disease and objectionable tendencies. In that relation the history of the individual may be of great importance and consequently must be sought. Is there story of eye trouble, such, for instance, as double vision? Is there history of ear trouble, such as earache, discharge, noises, or mastoiditis? What is the history as to enuresis, asthma, rheumatism, seasickness, swing sickness, vertigo, headache, and head injury? These questions relate to both disease and type and can readily furnish information upon which rejection should be based. A candidate whose history or condition shows lues, or any of the chronic intestinal disorders tending to dizziness, should be rejected, as well as he who is found to have inclination toward a habit that disturbs mental balance, such as toward alcohol or other drug.

(*i*) In either adult or minor a chest expansion of less than 2½ inches is a sufficient cause for the rejection of the applicant, and there shall be no variation below the prescribed chest measurements. In the case of minors no under weight or under height is allowed, and in regard to adults the weights given for 64, 65, and 66 inches will be regarded in each case as a minimum. No adult above 66 inches will be accepted with less weight than 132 pounds, and in such a case no variation greater than 7 pounds below the prescribed weight for height will be allowed. But in all cases the applicant must be active, with firm muscles, and evidently vigorous and healthy. Consequently, marked disproportion of weight over height will also be a cause for rejection when it is an indication of obesity. Special attention will be given to obesity and to any tendency in that direction disclosed by family history or suggested by disproportion of weight over height. Examiners will regard obesity or tendency to obesity as cause for rejection in all cases.

In addition to the usual physical examination to which candidates for the aviation corps now are subjected, I am of opinion that these candidates should be subjected to decompression tests in which their tolerance of oxygen partial pressure and the effects of greatly decreased air pressure may be demonstrated before such a demonstration is made in practice with possible fatal result from losing control of the machine.

The aviator's vital organs must be trained to accommodate themselves to changes of temperature and pressure incident upon ascents to high altitudes and descents from them, which ascents and descents are made with sufficient speed to tax greatly the accommodative power of the human organism. Rate of ascent should not be too rapid to

prevent adjustment of the body to diminished oxygen partial pressure, and descents should be slow enough to enable readjustment of the heart to atmospheric pressure at sea level.

The body possesses remarkable adaptability to varying air pressures. An English aviator is said to have risen to an altitude of 20,000 feet and returned to earth in twenty-one and four-fifth minutes. Such performances impose great strain upon the cardiovascular system. Physical discomfort upon the attainment of great altitudes seems less than might be expected. It is possible that diversion is a potent factor in reducing the appreciation of conditions which in other circumstances would make deeper impress upon the nervous system.

Air sickness, a condition analogous to seasickness, is not uncommon in those beginning to fly, especially if they meet "rough air."

The aviator's attention must be so fixed upon the operation of his machine that he has little time to think of his personal discomforts. He must steer in three planes, must go at high speed in order to prevent falling, and must keep his attention concentrated upon his complicated motor.

The duties are of such character as to make heavy demands upon the nervous system. Constant high tension, fear, anxiety in listening for defects in machinery, tax the nervous system especially. Von Schroetter says aviators suffer more nervous strain than balloonists who do not have to concentrate upon manipulation of the machine.

Captain H. L. Schurmeier, M. R. C., U. S. Army, made extended observations on a group of 20 men daily before and after flight over a period of six weeks and found the blood-pressure higher before ascent than after descent, unless the subject had had some disagreeable experience in the air.

Variations in diastolic and systolic pressures were in the same proportion. The differences of blood-pressure were more marked in those who were learning to fly than in experienced aviators. The differences in blood-pressure noted by Captain Schurmeier are at variance with those of some other observers who state that the blood-pressure is increased upon descent after flight. It is probable that this difference is more apparent than real, and that Captain Schurmeier's observations were made upon inexperienced fliers while the other observations alluded to were made upon experienced aviators.

Major Ralph N. Greene, Medical Corps, Florida National Guard, while he was serving as medical officer at the aviation post, Fort Sam

Houston, Texas, made a number of flights with aviators and took blood-pressure readings upon himself and his pilot at different altitudes. The Tycos instrument was used. He found that the normal readings on the ground were "110 to 120." At an altitude of 6000 feet the readings were 200, and this reading was not exceeded in rising to an altitude of 11,000 feet. It is assumed that the reading refers to the systolic blood-pressure. The observer does not state what the diastolic pressure was. He complained of "mild acceleration in heart action" and "an ever-increasing sense of roaring and tension in the head." He does not give any blood-pressure readings made after descent.

Huber ("Reference Hand Book of Medical Sciences") states that rapid descent at a rate four times faster than ascent causes vasomotor disturbances, rise of blood-pressure, and quickening of heart rate.

Chavez, after flying over the Alps at an elevation of 19,000 feet, fell fracturing both legs. He died later in delirium, and his death was attributed to vasomotor and myocardial disorder, resulting from his flight—not the fractures.

The duty of instruction is trying because of long hours spent in the air.

Flights of great altitude involve:

1. Decreased partial pressure of oxygen;
2. Lowered arterial blood-pressure;
3. Reduction in temperature of the air.

Permanent residence at high altitudes shows increase of red cells from seven to eight million per cubic millimeter. Since the body's demand for oxygen is constant, this increase in red blood cells appears to be Nature's effort to compensate for deficient oxygen partial pressure.

At an altitude of 12,000 feet vertigo and headache are experienced and the discomfort increases in proportion to ascent above this level. Nausea, sleepiness, and possible unconsciousness supervene. The low temperature causes chilling of the skin and compensatory increase of kidney function. At 18,000 feet even with the use of oxygen the discomfort is felt, especially the low temperature. At high altitudes the monotony of the whirr of the machinery, the hypnotic effect of the propeller, and the remoteness of fixed objects to engage attention tend to produce subconsciousness or hypnotic state.

Lapses of consciousness occasionally affect aviators and undoubtedly cause some of the accidents which are experienced by air men.

These lapses of consciousness may occur while the aviator is in the air or after descent.

An aviator has told the writer of an experience in which consciousness was lost at 17,000 feet and not regained until the 12,000-foot level had been reached. He was bleeding from nose and ears at this time.

The cause of this condition is obscure. Probably it is due to vasomotor disturbance resulting from sudden transition from a lower to a higher air pressure or *vice versâ*. It may be an exaggeration of the sense of giddiness often experienced upon rising suddenly from a recumbent posture while the heart is accommodating itself to the additional work suddenly thrust upon it. Hypnosis induced as result of monotonous noise of the motor, and absence of points of fixation for the eyes may be a possible cause.

The effect of inhalation of gasolene should be mentioned in this connection. Likewise inhalation of exhaust gases might produce unconsciousness by poisoning short of fatality.

So competent an aviator as Latham suffered this effect upon his nervous system when, in making an exhibition flight, he started to descend, and according to his statement was conscious of nothing after he had descended to a certain level until he landed with his machine on top of the grand stand, a happening calculated to rouse one to a conscious state from almost any condition.

Apparent unconsciousness is seen occasionally after descent. Its cause is not clear.

Speed necessary for the airplane to keep the air produces conjunctival congestion, and bright light causes photophobia and general ocular discomfort. This condition is known as "aviator's dazzling."

Crews of anti-aircraft guns are especially liable to irritation of conjunctiva and retina as result of careful watch of bright sky for the appearance of hostile aircraft.

Of all tinted glasses recommended to prevent "aviator's dazzling" "euphos" glasses probably are best, and should be worn as goggles. Eye glasses of any kind are apt to become fogged by moisture from the breath, or by oil when the so-called "tractor" type of machine is used. "Euphos," smoked or tinted glasses are a very necessary protection for the eyes during flight. There is much glare, especially in flying above the clouds, from which the sunlight is reflected in a very dazzling degree.

When flying over water there are certain conditions of the atmosphere which cause great confusion and accident at times. When the water is smooth the aviator has difficulty in determining its level upon attempting to descend to the surface.

One aviator who had no barograph in his machine thought he was about 5 feet above the surface of the water and leveled up his machine to land when his eye detected a buoy a long distance away and below him. By means of this buoy he realized that in reality he was about 1000 feet above the water. The horizon proves of value to the aviator in attempting to "land" on water, but there are certain conditions of the atmosphere which produce a mirage effect or which prevent identification of the horizon line. In such circumstances landing is difficult and dangerous unless buoys or other landmarks are present to indicate the line of demarcation between air and water.

The aviator ashore must be on careful lookout for overhead wires in ascending and descending, and in flight over the earth he constantly must examine the terrain subconsciously bearing in mind that accident may necessitate descent at any moment and clear space for landing may be needed.

The noise of the motor tends to produce temporary deafness in those who do not use cotton in the ears, and likewise the varying atmospheric pressures produce their effects upon the tympanic membrane. Unquestionably continued exposure will result in certain degrees of deafness.

Swallowing tends to equalize the air pressure on the inner side of the tympanic membrane with that on the outer, and should be kept up whenever uncomfortable pressure is felt in the ears.

Rainstorms produce much discomfort to the aviator (as also would hail or sleet). When the drops strike his face as the machine goes at a high rate of speed they are said to "cut like a knife" in addition to wetting and chilling.

Extreme cold causes its usual effects and considerable suffering to fliers. Subnormal mouth temperature has repeatedly been observed. The following means to alleviate this suffering have been employed:

1. The exhaust from the engine has been led into the space occupied by the aviator (fusilage), and, although these gases are poisonous if breathed in concentration, the heat imparted by them contributes to comfort.

2. Electrically heated garments are used in battle-planes.

3. The so-called Japanese stove may be used in pockets and within the clothing.

4. Special air-proof and water-proof clothing.

An emergency ration is provided, likewise a water supply.

At great altitudes, that is above 20,000 feet, oxygen apparatus may have to be used to generate oxygen for purposes of respiration. An apparatus similar to the so-called smoke helmet has been used with satisfaction. Oxygen is used by the fliers at the western front daily in making reconnaissances.

FIG. 102.—Launching a hydroplane from a ship.

It must be remembered that when oxygen partial pressure is reduced until life is supported with difficulty, combustion likewise is difficult and oxygen or compressed air must be carried for the motors as well. A fuel impregnated with oxygen may be developed.

Aviators are strapped in the machine in order that a minimum of injury may be experienced in case of accident to the plane.

If flying at high altitudes the aviator should be able to disengage himself from his machine in case of its falling and trust to the parachute which should be attached to him before his ascent.

Aviators belonging to the naval establishment spend considerable time on shore and are subject to endemic diseases of the locality in which they may be serving. For instance, malaria, dengue.

Ships from which aviators operate are confronted with the problem of launching the aviator. The catapult is an apparatus which has been devised for this purpose. It consists of a track on the deck of the ship which runs upward on an inclined plane in order that the aeroplane may gain as much elevation as possible when it clears the ship.

The aeroplane is placed upon a car on the track, and when all is ready, the aviator being seated, the propeller running at high speed, by means of compressed air and a cable, the car carrying the aeroplane is dragged rapidly along the track to its end, where the car, going at the rate of 45 miles an hour, hurls the aeroplane clear of the ship at a speed and elevation which enable the plane to continue its ascent without striking the water.

Surgeon Cottle, U. S. Navy, states concerning the catapult that "accidents to the machine are not infrequent, but they seldom injure the aviator beyond a wetting. Accidents serious enough to injure the aviator have resulted in death from the impact of the fall alone or from the combination of the stunning effect of the fall with drowning."

When the plane is about to be launched a motor launch containing a medical officer should be in the water ready for rescue in case of accident.

While the possibility of launching the aviator and his machine from the deck of a moving ship is admitted the practicability of the procedure when the ship is rolling considerably is problematical.

Granting the possibility of successful launching from a ship in a seaway the return of the aviator appears impossible in heavy weather. The machine would be seriously damaged if not lost in an attempt to land on a rough sea.

The captive balloon would seem to be safer than the aeroplane for coöperation with naval forces in any weather except a smooth sea.

CHAPTER XVIII

SUBMARINES

General Type.—Submarine vessels correspond in general shape to the ordinary ship, but are strongly constructed in order that they may withstand the pressure resulting from submergence to about 300 feet. They vary in size from 500 to 1000 tons, and carry a crew of about 25 men. Submarine vessels at present are used exclusively as war vessels. When running on the surface they are propelled by oil engines, and when submerged, by electric storage batteries.

When the vessel is running on the surface in a smooth sea the hatch leading into the conning tower and also other hatches on the upper deck of the craft may be left open, thus facilitating natural as well as artificial ventilation. In a moderately rough sea, when all openings must be closed except the small ventilating tube, accompanying the periscope, which tube supplies air to the forward part of the ship, the conditions become very uncomfortable. When the ship submerges all communication with the outer air is closed.

When submarines are at the dock or at anchor and are charging the storage batteries the fumes from the exhaust often are blown in such way that those on the bridge or deck must breathe them. The fumes gain access through the open hatches or a ventilating intake into the boat itself.

When running submerged this condition is not so marked since the boat is then propelled by an electric storage battery. Less discomfort is experienced by the crew during a submergence run of several hours than during a run of similar duration on the surface. The storage batteries do not vitiate the air to the same extent as the oil engines.

After a series of observations made on board a submarine, Surgeon E. W. Brown, U. S. Navy, and Naval Constructor McEntee, U. S. Navy, recommend that the concentration of oxygen should not be permitted to fall below 15 per cent. and that the percentage by volume of carbon dioxide be not allowed to exceed 2 per cent.

These observers found that the consumption of oxygen averages 0.9 cubic foot per man per hour.

The crew of a submarine lives in a per capita air space far below that regarded as a minimum aboard ships.

The initial volume of air soon is vitiated beyond acceptable standard by:

1. Human beings; and
2. Materiel.

1. Human beings add to the air:
   (*a*) Carbon dioxide;
   (*b*) Humidity;
   (*c*) Emanations from skin, clothing, excreta, alimentary canal, (feces, flatus and vomitus from seasickness), and food or its preparation;

and they withdraw oxygen from the air.

2. Materiel adds to the air:
   (*a*) Heat from illumination and from machinery in motion;
   (*b*) Gases from fuel oil or from its combustion (whether complete or incomplete);
   (*c*) Gases from storage batteries;
   (*d*) Emanations from lubricant materials.

Surgeon Kress of the U. S. Navy has shown that the number of microörganisms in the air on submarines during submergence is greatly reduced, indeed there are fewer organisms present per cubic meter than when the ventilation is at its best. He attributed this to the high humidity and absence of dust particles, comparing the condition of the air with that of the interior of large sewers, where the atmosphere is remarkably free of bacterial content because of the absence of dust.

He found an average of 2800 organisms per cubic meter in the several compartments of a ship studied by him as she lay at the dock, and later at sea found an average of 500 organisms per cubic meter in the same spaces. He attributed this to the "aspirating action of engines and suction of ventilators leading from battery compartments into the batteries." Undoubtedly this is in part correct, but since the ship had been cruising on the surface the air taken in probably was almost sterile as it entered the ship.

The distance of the ship from the shore was not stated, but since she was on a thirty-six hour endurance run it is possible that she was approximately 100 miles from shore, at which distance sea air is practically sterile.

Ventilation.—The ventilation of submarines is a problem which has occupied the brightest minds of naval constructors and sanitary engineers for some time past. The crew of the submarine performs

its duties under conditions which may be compared to those at the bottom of a large bottle. The facilities for air interchange are totally inadequate for the needs of the crew at rest, far less so when they are at work. Further to complicate the problem of ventilation the submarine is divided into several water-tight compartments, some of which contain machinery, storage batteries, living spaces, torpedo tubes, air tanks, etc. For some time the difficult disposal of excreta added its discomforts to the conditions under which the crew had to live. The relative humidity is usually high, and during submergence the heat generated by machinery causes additional evaporation and more nearly approximates saturation for temperature.

The ventilation of the submarine running on the surface is difficult enough, but the problem is greatly increased during submergence. In temperate climates the temperature during submergence is low, and indeed during the winter submarine cruising is full of discomfort because of the low temperature and great humidity within the vessel.

The oxygen in the available air supply of the submarine may be reduced to about 16 per cent. before distress is felt. The problem is to remove the carbon dioxide and vitiating gases rather than to supply oxygen.

Various processes (chemical and mechanical) have been devised for removal of vitiated air in submarines, as well as for the removal of humid heated air. For military reasons secrecy concerning these devices is observed by the several nations. It appears probable, however, that a system of rebreathing after passing the vitiated air through chemical processes and adding oxygen may be employed satisfactorily. This would be the application of the principle of the smoke helmet on a large scale.

The principal pollutions of the air due to materiel in submarine boats are:

(*a*) **Hydrogen** evolved from the battery plates during charging of storage batteries, and even when charging actually is not going on a small amount of hydrogen is given off. If the concentration of this gas in the air becomes so great as 8 to 10 per cent. an explosive mixture is formed which may be set off by the sparking of an electric motor, lighting of a match, etc., and disastrous consequences may follow. Hydrogen detectors are now in use.

(*b*) **Sulphuric acid fumes** occasionally are evolved from the accumulators.

(*c*) **Chlorine** may be rapidly generated as the result of sea water coming into an electric circuit. The water is electrolyzed between the poles of the circuit, and the compartment may be quickly filled with sufficient chlorine to make the air irrespirable. This may occur either as result of accident to wires or constant entrance of salt water into the accumulator cells.

(*d*) **Carbon monoxide** may be generated as the result of incomplete combustion of the gasolene used for propulsion when the boat is running awash. This difficulty, however, has been almost overcome and only by accident is the air apt to be polluted in this way.

(*e*) The **fumes from the fuel oil** tanks may attain considerable concentration in certain compartments and become very objectionable. When gasolene fumes attain a concentration of 2 per cent. of the atmospheric air an explosive mixture is formed. The odors from oils, paints, preparation of food, garbage and water closets all contribute to the further pollution of the air in the vessel.

Variations in temperature are great. The boats, although heated by electricity, are almost always quite cold in temperate latitudes, especially the outer plates whose temperature is influenced by the water in which the ship lies. As the result of the chilling of these plates there is much condensation of aqueous vapor from the atmosphere within the submarine. Sleeping and work billets should be as far from the plates as practicable in order to prevent chilling, colds, and respiratory diseases. Insulation of the outboard plates with wood or cork is desirable in order to limit the chilling of work stations and sleeping spaces.

In the tropics the temperature and humidity may become very high. At such times the conditions become almost unbearable.

The compressed air contained in the huge flasks or tanks is a hygienic advantage. It is used primarily for the purpose of producing additional buoyancy when the ship is submerged, thus bringing her to the surface, but the compressed air also is available as an emergency air supply, and the duration of submergence may be prolonged several times by turning on the compressed air supply for respiratory purposes.

Air in the compressed air tanks is under high pressure and when allowed to escape into the trimming tanks it forces out the water, thus increasing the buoyancy of the boat and enabling it to rise.

An electrically driven turbine pump also may be used to expel

water from these tanks when it is desired to bring a submerged boat to the surface.

Artificial ventilation is employed in several different ways on board submarines. First, by aid of blowers the circulation of air is maintained throughout the ship. This circulation merely agitates and diffuses the air and causes additional comfort by facilitating evaporation from the skins of the crew. Such a system may be used to take in fresh air from without through ventilating tubes and hatches when the vessel is on the surface or partially submerged. But when submergence is completed the gate valves in the ventilating tubes must be closed to prevent entrance of water, and the function of the mechanical system (blowers) is merely that of maintenance of circulation of the contained air, regardless of its purity or impurity.

This initial volume of air soon will become vitiated during prolonged submergence, and in such circumstances the air must be altered, either by the admission of fresh air from the compressed air tanks, or by the removal of carbon dioxide and water vapor from the air and the addition to the air of oxygen from tanks in which compressed oxygen is carried. The carbon dioxide and water vapor are removed by forcing the air through appropriately contained granules of the following composition:

Potassium hydrate	19.3 per cent.
Sodium hydrate	66.21 per cent.
Sulphuric acid	1.30 per cent.
Hydrochloric acid	0.66 per cent.
Water	12.52 per cent.

The above analysis gives the composition of granules in use in the Italian Navy (from translation by Medical Inspector J. S. Taylor, U. S. Navy, of description by Dr. R. Marantonio, Major Medical Corps, Royal Italian Navy).

In certain parts of the ship, for instance storage batteries and combustion motors, the vitiated air may be drawn into foul air tanks, compressed, and expelled from the boat into the water in which she is submerged.

Loss of Weight.—The complaint is commonly heard that men in submarines lose weight rapidly. Observations do not confirm this. Seasickness, lack of exercise, limited sphere of activity, inhalation of gas fumes, and in tropical latitudes the temperature, all serve

to diminish the appetite and general sense of well being, and tend to result in temporary loss of weight due to disturbance of metabolism.

No doubt the small uncomfortable toilets are a factor in producing the constipation common among submarine crews. Water closets of the pump variety are used below the surface. When running on the surface a temporary "head" or water closet is installed on deck.

Members of the crew should be instructed to come for a laxative if the bowel is not emptied regularly each day.

The stressful conditions of submarine duty tend to develop mental symptoms in individuals who would not exhibit them in normal circumstances.

The Effect on Hearing.—The great humidity together with the drafts caused by artificial ventilating apparatus upon men who are overheated tends to produce colds and disorders of the nose and throat. More important, however, is the effect of service on submarine boats upon hearing.

As result of diving the increased pressure caused by the escape of air from the air flasks within the boat (this amounts to about ½ pound) the sense of hearing becomes gradually duller, and finally a considerable degree of deafness results.

The inhalation of gases and fumes from oil tanks and batteries, constant vibration due to the machinery, as well as cold drafts, appear to be the probable causes of this deafness, either by provoking catarrhal conditions which extend to the middle ear and produce permanent injury, or by the mechanical effect upon the auditory nerve produced by the constant vibration.

Effect on the Nervous System.—The noise and vibration of machinery in the confined spaces produce serious effect upon the nervous system, and together with the bad air cause headaches, auditory disturbances, "gasolene palpitation," irritability, insomnia, and not uncommonly men are overcome by gasolene fumes. The constitutional effect of gasolene fumes resembles the stage of excitement in alcoholic intoxication, and has been aptly called the "gasolene jag." Surgeon McDowell, U. S. N., states that some of these cases show disordered mind, but no muscular incoördination, merely becoming confused mentally, then comatose.

Later workers regard the so-called "gasolene jag" as *carbon monoxide poisoning* of mild degree.

A feature not to be overlooked is the making of urgent repairs

which often overtaxes the efforts of the workers which are put forth under bad living conditions. The crews of submarines also are subjected to considerable exposure due to wetting as the result of running awash, and consequently are predisposed to tonsilitis, rheumatic and respiratory infections.

Injuries through machinery are common, and electrical burns also are to be mentioned. **Burns** due to accidental contact with sulphuric acid are common, as the acid is used in the batteries. As result of prolonged exposure to unfavorable living conditions, not the least of which is the inability to take proper exercise, anemia and digestive disturbances of all kinds are common among submarine crews, and the lack of proper laundry facilities as well as facilities for personal cleanliness predisposes to skin infections and cellulitis.

Conjunctivitis is commonly caused as result of fumes from batteries. Prolonged watch at the periscope is apt to result in eye strain, but there has been comparatively little complaint concerning eye strain of this character because the vessels are submerged as little as possible, running on the surface when practicable.

The lack of appropriate facilities for the care of fresh foods greatly limits the choice of food which may be carried. The lack of variety and the difficulty in getting fresh food tend to produce **digestive disturbances.**

The preparation of food is difficult, and the washing of mess gear is unsatisfactory because of lack of fresh hot water.

Men detailed for submarine duty should be required to undergo an extremely rigid physical examination with special reference to the nervous system, and none who have active disease or whose previous history includes syphilis should be permitted to go on this duty. It should be remembered that the facilities for caring for sick on board submarines are nil, and that the vessel may be required to operate at such distance from base, mother ship, and hospital ship that the prompt transfer of sick or injured could not be effected. Carriers of infectious disease should not be permitted to go on board submarines.

Surgeon Kress, U. S. Navy, has observed in several cases a moderate albuminuria which he attributes to inhalation of fumes of fuel oil. These cleared up promptly after a few days' absence from what was regarded as the exciting cause, namely the fumes.

An **"escape apparatus"** has been devised to enable escape from submerged submarines which are unable to return to the surface.

The essential feature of this dress is an apparatus which permits respiration independently of atmospheric air just as the so-called "smoke helmet," or the shoal water diving suit in use by the Germans.

The **accidents to submarine boats** occasionally result in loss of life even of the entire crew. There are so many possibilities that it seems remarkable that more accidents have not occurred. For instance, several years ago the Russian submarine Minoga was preparing to submerge. Some signal flags lying on the deck and across the coaming of a water-tight hatch prevented the complete closure of the hatch. When the boat submerged water came rapidly in through the partially closed hatch and altered the trim of the vessel so quickly that she sank. After submergence of about nine hours the entire crew was rescued.

The German submarine U-3 about to submerge, sank as result of entrance of water through a ventilating tube, the valve of which was not closed. These two instances are cited to indicate how rapidly disaster may result from failure on the part of the personnel to perform fully their duties.

Other accidents, as in the case of the U. S. S. F-4, have occurred in foreign navies as well as our own, and the causes of them probably will remain among the mysteries of the great deep. The vessels have submerged and have not come to the surface. When the vessels have been found the reasons for the accidents have not been apparent, but it appears very probable, except in time of war when submarines are sunk by gun fire or mines, that the deaths of the occupants have been due to suffocation of some character.

CHAPTER XIX

DIVING

Diving often is necessary for:

(*a*) Recovery of human bodies;
(*b*) Repairs to the underwater hull of a ship;
(*c*) Clearing of propellers which have been fouled;
(*d*) The recovery of torpedoes during target practice;
(*e*) Recovery of lost property.

On the surface of the water the diver is under an atmospheric pressure of 14.64 pounds per square inch, or "one atmosphere." In his descent he subjects himself to a pressure which increases directly in proportion to his depth from the surface. For each 33 feet of vertical descent below the surface the pressure increases "one atmosphere," in other words there is an increase of about 15 pounds pressure per square inch for each 33 feet of descent.

Consequently each square inch of body surface bears, including the pressure of the air at the surface, approximately:

A pressure of 30 pounds (2 atmospheres) at a depth of 33 feet;
A pressure of 45 pounds (3 atmospheres) at a depth of 66 feet;
A pressure of 60 pounds (4 atmospheres) at a depth of 99 feet;
A pressure of 75 pounds (5 atmospheres) at a depth of 132 feet;
A pressure of 90 pounds (6 atmospheres) at a depth of 165 feet;
A pressure of 105 pounds (7 atmospheres) at a depth of 198 feet;
A pressure of 120 pounds (8 atmospheres) at a depth of 231 feet;
A pressure of 135 pounds (9 atmospheres) at a depth of 264 feet;
A pressure of 150 pounds (10 atmospheres) at a depth of 297 feet.

To meet these great pressures and the oxygen exclusion caused by the water, man must resort to artificial conditions for maintenance of life if submergence is to be continued longer than three to four minutes and if considerable depth is to be reached.

In the pearl fisheries at Hiqueru in the South Pacific Ocean I witnessed a remarkable dive. Upon approaching the small boat from which the diver was about to descend he was found to be clad in a loin cloth and a friendly smile. A peculiar

moaning sound was heard which, upon arrival at the boat, was found to be due to prolonged noisy expiration after deep inhalation. When making deep dives, the lungs are aerated thoroughly by rapid deep inhalations (the expirations producing the moaning sound above referred to) for a period of from fifteen minutes to one-half hour. During this period rubbing the limbs probably facilitated thorough oxygenation of the tissues.

When about to dive the diver took a very deep inspiration immediately before entering the water, gently lowered himself feet first, turned in the water, and swam downward. He carried a small piece of shell not so large as the palm of the hand, using it to detach the pearl oyster from its bed.

He descended to a depth of seventeen and one-half fathoms (105 feet) and returned bringing several pearl oysters with him after a submergence for a period of two minutes and forty-three seconds.

In this dive no untoward symptoms followed the brief stay of the diver under an absolute pressure of about 60 pounds per square inch.

Hill and Flack have shown that forced breathing for six minutes results in ability to hold the breath for four minutes and five seconds. They also showed the "breaking point" to be when the partial pressure of alveolar carbon dioxide equals 6 to 7 per cent. of an atmosphere and the oxygen pressure had become reduced to 9 to 10 per cent. of the atmosphere.

Goldfish have been subjected to 1000 pounds pressure (about 66.6 atmospheres) and upon release of pressure were limp, but after a short time adapted themselves to the normal atmospheric pressure and swam about with no apparent bad results. This tolerance of great pressure by vital tissue is shared to a lesser degree by man.

Under supervision of Surgeon French, U. S. Navy, and Chief Gunner Stillson, dives to a depth of 306 feet were made about the wrecked submarine U. S. S. F-4, near Honolulu. The pressure at this depth equals 7047 millimeters of mercury. The oxygen partial pressure amounted to 1452 millimeters of mercury.

Diving in deep water requires that the diver operate in a diving dress which in principle is a chamber in which air compression and decompression may be made through a flexible air hose communicating with the air pump or compressed air flasks on the surface.

The diving apparatus consists of:

1. A rigid helmet and chest piece. The helmet has water-tight glass windows, and has an electric light and telephone attached;
2. A water-proof dress, being elastic and fitting snugly at the wrist;
3. Two 40-pound lead weights for front and back;
4. A pair of weighted boots weighing approximately 25 pounds each;
5. A life line;

6. A wire-wrapped flexible air tube having metal couplings connecting the diver's helmet with

7. The air pump on the surface.

FIG. 103.—Navy standard diving dress. Note the air tube leading from an air-pump which is not shown; also the telephone by which the diver may speak to an operator on the surface. The helmet is rigid to protect the head. The shoes are heavily weighted.

The total weight of the diver's dress exclusive of pump and air tube is about 175 pounds. In such a suit a man at rest exhales 0.84 cubic

foot of carbon dioxide per hour and 2.7 cubic feet when at work. The resting adult breathes about 15 cubic feet of air per hour. The rate of respiration is physiologically adjusted so as to maintain an alveolar tension in the lungs of 5 per cent. of one atmosphere.

A satisfactory diving suit must:

1. Remove carbon dioxide and exhalations from the diver;

2. Supply fresh air of moderate temperature;

3. Supply the air with increasing pressure as the diver descends, equal to or greater than the water pressure surrounding him, and must supply a **volume of compressed air equal in volume to that required by the diver at the surface.**

Under pressures so great as six atmospheres there does not seem to be increase of carbon dioxide output from the lungs. When the diver is at rest carbon dioxide should not be permitted to increase within the diving suit to a tension above 3 per cent. of one atmosphere, and during work a tension of not more than 1 per cent. of an atmosphere should be maintained if possible. To keep the carbon dioxide at 3 per cent. he should have ($0.019 \times 100 \div 3 = 0.63$ cubic foot per minute) and during work ($0.045 \times 100 \div 3 = 1.5$ cubic feet per minute). These volumes of air should be delivered within the diving suit on the surface.

In descending the water pressure increases one atmosphere for each 33 feet of descent, or one thirty-third of 14.7 pounds for each foot. In order to withstand the water pressure air is delivered within the diving suit so as to counterbalance the pressure from without and to keep the diver from being squeezed.

Following Boyle's law the volume of air decreases inversely with the pressure upon it, therefore a cubic foot of air at the surface would at 33 feet below the surface be compressed to one-half its volume. At 66 feet or an absolute pressure of three atmospheres, the cubic foot would be compressed into one-third its volume; at four atmospheres, one-fourth its volume, and so on.

On the surface the diver's demands are about 15 cubic feet of air per hour. This volume is a constant and must be maintained regardless of pressure. In other words, if the diver is surrounded by water which is producing an absolute pressure of five atmospheres he must be supplied with 15 cubic feet per hour of air compressed to five atmospheres.

When measured at the surface this air would be five times the volume for the surface requirements of the diver, or 75 cubic feet.

He must receive constantly the volume (15 cubic feet per hour) of air normally required by the adult at sea level. This volume of air

FIG. 104.—Diving dress, rear view.

must remain constant no matter what water pressure the diver goes into. If the volume must remain a constant as the pressure increases it is evident that two, three, or four times, and so on, the volume of his

allowance on the surface must be compressed for delivery to him of the necessary volume when he is under a corresponding number of atmospheres of water pressure.

It is desirable that the air pressure within the diver's suit exceed the water pressure on the outside by about ½ pound. This condition gives greatest comfort to the diver, and if the necessary volume of air be supplied the pressure within the diver's dress may be regulated by a small outlet valve which is placed in the upper part of the dress, either in the helmet or breast plate. It has been found more comfortable to have this outlet valve located in the breast plate at about the level of the shoulder.

When working with hands above the head sufficient water may enter the diver's dress at the wrists to cause a certain amount of wetting and chilling. This should be guarded against by him.

Excessive inflation of the diving suit is undesirable and may result in the diver being blown to the surface. This accident would prove very dangerous to life if he were blown up from great depth. It has been found best to put a lacing around the legs of the dress to prevent undue inflation which might result in the diver's inability to maintain his equilibrium as result of buoyancy of his lower extremities. Care must be exercised that the diver's signals are promptly heeded, for in case of fall of considerable vertical distance uncomfortable if not dangerous "squeeze" might result.

In the deep dives made about the U. S. S. F-4 an air pump was not used, but the dress of the diver was ventilated with air compressed in torpedo flasks from which it was supplied through a manifold and controlled by appropriately placed valves and gauges.

A diving dress has been devised which enables the diver to operate in shoal water not exceeding 33 feet without air-pump connections, and merely a life-line attached. This dress is similar in character to the diving dress above mentioned except that instead of an air tube and air-pump connections the diver carries on his back an apparatus which connects with the interior of the helmet. The apparatus operates upon the principle of the smoke helmet used in mine rescue work; the air is expired through certain chemicals which abstract the content of moisture and carbon dioxide, and the oxygen deficit is supplied from a tank of compressed oxygen which is appropriately controlled.

This apparatus enables the diver to remain submerged at a depth not exceeding about 35 feet for a period of two hours.

Hall and Rees have devised a dress for use on submarines in case of accident, its purpose being to enable the escape from the submerged vessel. The essential feature of the dress consists in an incompressible helmet having an air-tight window closed with glass and an apparatus through which the occupant of the dress exhales, the carbon dioxide and moisture of the expired air being absorbed by "oxylite," oxygen being added. The principle of this apparatus is similar to that employed for the maintenance of life when the smoke helmet is used. It has been suggested that by proper weighting this dress may be used for diving in shallow water.

When gases are compressed in the presence of fluids they are absorbed by the fluids until a point of saturation is reached. The body of the diver presents no exception to this rule. His blood and tissues absorb the compressed air to a point of saturation.

If the diver comes to the surface too rapidly his body tissues and fluids come under greatly reduced degree of pressure and his condition is analagous to that of a charged mineral water bottle. The sudden release of pressure permits the rapid expansion of the compressed air with its consequent disrupting effect upon the tissues. Fatty tissues absorb nitrogen most rapidly and give it off rapidly. Hence this constituent of the brain and nervous system is apt to suffer most in the disruptive effects caused by too rapid decompression.

The longer the diver is under pressure, the more dangerous decompression becomes.

The diver may descend as rapidly as it is possible to deliver the air necessary to prevent squeeze during his progress, but his ascent must be made very differently. The duration of it will depend in part upon the degree of pressure to which he has been exposed, and the duration of that exposure. It has been shown above that the pearl divers, unaided by diving dress, exposed themselves to an absolute pressure varying up to about five atmospheres, and after remaining under such pressure for a minute or two returned to the surface and often experienced no ill effect. A similar performance may be repeated in the diving dress, but if the diver is to make a stay of any duration at the pressures above mentioned his return to the surface cannot be immediate, but must be made by stages, and with delay at each stage.

It has been found that if the tissues are saturated at a given absolute pressure this pressure may be reduced to one-half without any

risk, but a reduction of pressure in excess of one-half the absolute pressure at which the tissues were saturated is dangerous.

A diver at a depth of 99 feet is under four atmospheres absolute pressure, and may ascend until he has reached half way to the surface, where he should stop to enable his tissues to accommodate themselves to the lowered air pressure at that level before further ascent. While ascending he should work his arms and legs to aid in the expulsion of the nitrogen from the tissues.

Too rapid return to the surface following prolonged exposure to pressures greater than two atmospheres absolute pressure usually results in extremely painful and dangerous symptoms. The rapid liberation of nitrogen gas causes the formation of bubbles of nitrogen in the various tissues of the body. The effect of this varies with the tissues involved.

In the milder cases the first symptoms are pains in the muscles and joints. These may become very severe and embarrassment of breathing and heart action follow as result of bubbles in the circulatory system and lungs. Unconsciousness, cyanosis and great shock appear. There may be marked distention of abdomen. Ecchymoses may appear. The agonizing pains in the muscles and joints have given this condition its common name, "the bends."

The more dangerous effects are manifested upon the nervous system. The disruptive action of the liberated nitrogen may strike vital centers and result in immediate fatality, and temporary or permanent paralyses may follow immediate destruction of motor centers or injurious compression resulting from hemorrhage.

Under ordinary conditions return to the surface should never be so rapid as to allow symptoms resulting from too rapid decompression. If for urgent reason it is imperative to depart from the method of procedure which experience has shown to be safe, or if the diver has been blown up to the surface as result of excessive inflation of his dress, he should be "recompressed" immediately, being sent down under water rapidly upon the appearance of the first symptom of "bends."

A recompression chamber on base ships is very desirable and has proved useful in the British Navy during the war now in progress.

Men who are to engage in diving should be selected by physical examination of severity second only to that given for aviation duty. Young, wiry, robust individuals should be selected. The condition

of lungs, heart, blood-vessels and nervous system should be studied most carefully. Those addicted to abuse of drugs, alcohol or tobacco should not be permitted to dive. Persons past forty years of age and those having history suggestive of sclerosis of blood-vessels also should be eliminated. Owing to the rapidity with which fat absorbs nitrogen, its power to absorb this gas in much greater quantity than other tissues, and its tendency to give off its large volume of absorbed nitrogen rapidly, fat men are undesirable. The diver should be young, strong, lean, and free of organic disease.

CHAPTER XX

SWIMMING

Drowning causes a greater number of deaths in the United States Navy in time of peace than any disease or accident. It caused over 19 per cent. of the deaths in the United States Navy during the seven years from 1910 to 1916 inclusive. (The average actual number of deaths per annum was 299.5 and of these drowning claimed 57.5 men each year.) This exceeds by far the next greatest cause of death in the Navy, viz., tuberculosis. Gatewood says that 28 per cent. of deaths afloat are due to drowning.

In certain cases of drowning, for instance in the fatal submergence of the U. S. S. F-4, it is probable that the most skilled swimmer could not have survived, yet it is not improbable that the annual number of deaths due to drowning would be reduced materially if the personnel of the service were possessed of a greater degree of excellence and confidence in swimming.

While working on the ship's side it is not an uncommon occurrence for men to fall overboard, and even a slight knowledge of swimming would enable them to stay up until rescued.

During severe winter weather in New York a side cleaner slipped on the ice which lay on the armor ledge of the North Dakota, and fell into the water below. Luckily his head did not strike any of the large masses of floating ice and his ability to swim enabled his rescue. He was badly shocked by fright and cold when brought in for treatment.

Each individual in the naval service should undergo compulsory instruction in swimming and should not be excused except upon certificate of medical officer. Persons suffering with disease of ears, sinuses, heart, lungs, or kidneys should be excused.

While instruction in swimming should be compulsory it should be gradual, should inspire confidence, and should not be of character to produce great fright, especially in those who tend toward mental instability.

While serving on the U. S. S. North Dakota I saw a case, X, in which mental imbalance followed fright as result of his being urged to jump overboard in deep water in an effort to qualify in swimming. Being unable to swim and unwilling to make objection, he jumped, struggled in the water, was rescued, and little further was thought of the incident until swimming call was sounded the following day. This call was for voluntary swimmers.

Being hurriedly called on deck to treat a man who was said to be apparently drowned, I found X unconscious, lying on the forecastle of a steam launch upon which he had been dragged out of the water. He was partially clad. Eye witnesses said they had left him asleep under the overhang of No. 1 turret when they started for their afternoon swim. The next they saw of him was when he was recognized as a

FIG. 105.—Swimming drill. Learning leg motions. (*Medical Inspector J. A. Murphy, U. S. N., in United States Naval Medical Bulletin.*)

struggling man among the group of swimmers and apparently drowning. A part of his clothing was found near turret No. 1 where he had removed it just before his plunge into the water, which must have been from the main deck or from the deck of the ship's forecastle, distances of 16 and 22 feet respectively. No one saw him jump. As many were diving from the ship he attracted no attention.

He was resuscitated but remained in a state of stupor for a day or so, and when finally he became conscious it was evident that a psychosis had come to the surface, and the unfortunate man had to be invalided to a hospital for care of such cases.

Instruction in swimming should be begun out of the water. Where a number of persons are to be instructed a dry swimming drill will enable them to acquire the proper muscle sense and execution of the necessary movements. The first drill should be in the standing position.

FIG. 106.—Learning arm and leg motions out of the water. Preparing for the thrust of arm and leg. (*Murphy, Naval Medical Bulletin.*)

FIG. 107.—Learning arm and leg motions out of the water. The thrust. (*Medical Inspector J. A. Murphy, U. S. N., in the U. S. Naval Medical Bulletin.*)

After the proper **motions of arms and hands** are learned instructions may be given to the pupils lying across benches on their abdomens. This posture simulates more nearly that of the swimmer and the exact **rhythm of leg and arm motions** can be learned to better advantage.

The pupils are now ready to be taken into water shoulder deep, where sustained by floats or life preservers confidence is established, and the swimming strokes can be practised. After a lesson or two free swimming should be begun, the instructor keeping careful watch that the pupils do not acquire faulty strokes which tend to retard the thrust and cause drag.

FIG. 108.—Learning the motions of both legs. (*Murphy, United States Naval Medical Bulletin.*)

Swimming Tanks.—If possible the instruction in swimming should be given in the pools at training stations before the individuals are sent on board ship. If this cannot be done the first opportunity should be seized to teach swimming. No diseased person or carrier of infectious disease should be permitted to enter the swimming pool, and all persons should be required to take a cleansing shower before entering it. Persons having sore throats, tonsilitis, respiratory or skin infections should not be permitted to enter the swimming tanks.

The water in the tanks should be changed as often as possible. When the temperature of the water is low enough to require that the water be heated, the changing of the contents of the pool will neces-

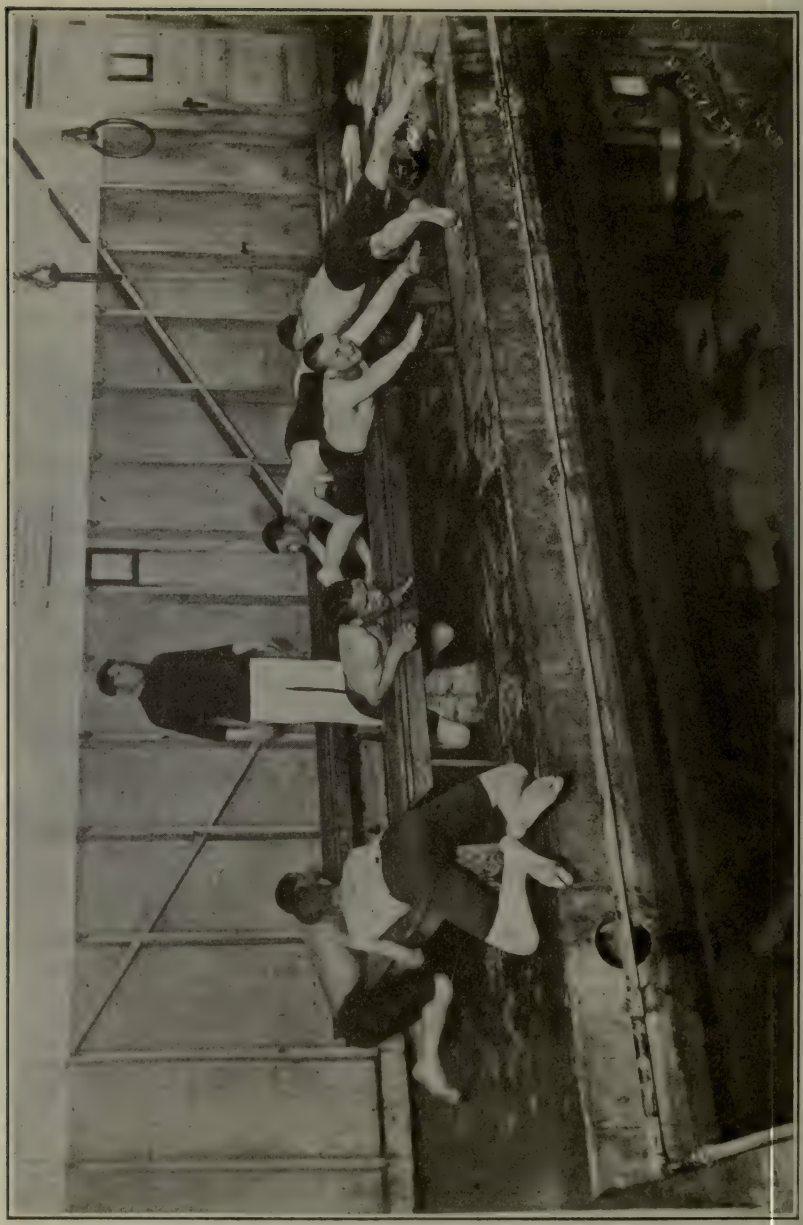


FIG. 109.—Learning coördinated movements of arms and legs out of the water. (*Murphy, Naval Medical Bulletin.*)

FIG. 110.—In the tank. Instructors teaching and ready for rescue. (*Murphy, Naval Bulletin.*)

sarily be less frequent. In such circumstances the water should be treated with calcium hypochlorite in proportion 1 to 500,000. Probably this is best applied by placing calcium hypochlorite, containing not less than 30 per cent. of available chlorine, in gauze bags and drawing them through the pool.

This sterilization should occur at least weekly, since the warmed water containing epithelial débris from the bodies of the bathers constitutes an excellent culture medium for pus organisms. This method has been found very satisfactory and has effected practical sterilization of highly infected water.

At Brown University the process has been employed most satisfactorily for the purification of water in the swimming pool of the gymnasium. For some reason it was found impracticable to refill the tank oftener than once every three months. Obviously such infrequent change of the water, which probably was heated, and which would acquire pabulum sufficient to maintain bacterial life from decomposing epithelial scales, etc., derived from the swimmers, would be a great source of danger provided, for instance, the water became polluted by a typhoid carrier. Chemical purification was desirable and the hypochlorite method was employed. It is said that water containing 500 organisms per cubic centimeter was sterile one hour after employment of the method.

Whether in the pool or elsewhere swimming should not be permitted if the temperature is below 70°F., and if the temperature of the water is below 85° swimming for a period longer than fifteen minutes should not be allowed.

With reference to meal hours, **swimming before meals is preferable,** and after meals should not be indulged in within two hours. In the tropics it is desirable that swimmers enter the water while the sun is low, either before 9:00 a.m. or after 4:00 p.m. in order to prevent the severe sunburns often resulting from exposure to the intensity of the sun's rays.

High dives are dangerous and injury is apt to follow their attempts by unskilled swimmers. During the flight through the air the would-be diver often changes position, so that instead of breaking the water with the tips of his fingers and the body following arrow fashion, he falls in such way as to strike dorsal, lateral, or ventral surfaces of the body upon the incompressible water, and the consequent shock may result in unconsciousness and drowning. Those making high dives very commonly suffer muscle strains and bruising.

The sudden change of pressures as result of diving is apt to cause ear disease. Infections of the middle ear are very common among

swimmers and may be prevented in part by the insertion into the ears of cotton which has been soaked in sweet oil, albolene, vaseline, or some other bland oily substance. This will prevent the entrance of water into the external auditory canal, but of course cannot prevent the admission of sea water to the middle ear through the eustachian tubes.

When ships are at anchor in a harbor near a city swimming should be permitted only during flood tide, preferably just before the turn, in order that the sewage from the city may be avoided when it is carried out by the ebb.

Also all water closets and bathrooms emptying from the side of the ship along which swimming is to take place should be closed at least for one-half hour before the water is entered and during the time that the swimmers are in the water.

Swimming from the ship should be restricted to short distances, and a life boat containing an expert swimmer should be lowered before persons are permitted to enter the water.

The boat's crew should be carefully trained in the resuscitation of the apparently drowned. Life preservers and life lines should be made ready on the deck of the ship, and men should be detailed to stand by to throw them promptly in case of apparent danger to any swimmer.

The grab line, which extends almost the entire length of the ship, should be lowered until it is awash and should be shored from the ship's side or guyed from the boat booms so that it is well clear of the side in order that the line may be grabbed easily, and that swimmers seeking its aid may not be cut by barnacles which may be growing upon the ship's side.

Prolonged stay in cold water tends to produce cramps in muscles of the extremities and abdomen. This may well result in the drowning of a strong swimmer if help is not at hand.

Unauthorized swimming should be prohibited. In strange localities unobjectionable local conditions should be established before swimming is allowed.

For years it was the custom to permit daily swimming alongside the German training ships which lay in the Kiel Canal quite close to land. During one summer several cases of pneumonia with suppuration (Lungenbrand) developed. The medical officer of the brig Rover noticed one day that a large pus-saturated bandage was discharged into the water from the mouth of a sewer which emptied in the vicinity of the brig. This sewer also carried the sewage from the university

hospital. Swimming alongside was forbidden, and lung suppurations no longer occurred.

Swimming in land-locked harbors should not be allowed especially if many vessels are at anchor or much sewage is discharged into the harbor. The pollution of the water in such harbors may be increased as result of ships bringing water ballast from infected harbors and discharging it at the port of arrival.

Swimming about the mouths of rivers may be especially dangerous. The International Joint Commission on the Pollution of Boundary Waters reported concerning the water at the mouths of the Detroit and Niagara Rivers that "serious pollution extends over 10 miles into the lake receiving the discharge."

CHAPTER XXI

RESUSCITATION OF APPARENTLY DROWNED

The Surgeon General's report for the year 1917 shows that drowning heads the list of causes of death in the Navy as it has for several years past. During 1917 seventy-four deaths from drowning (five of which were suicidal and thirty-six due to the disaster to the U. S. S. Memphis) occurred. Such common cause of death in the Navy calls not alone for special instruction in swimming but also requires that each member of the naval personnel be thoroughly instructed in methods for resuscitation of the apparently drowned. These methods are (*a*) manual and (*b*) mechanical.

(*a*) **Manual.**—The **Schaefer method** is the best of the several manual methods which have been devised for resuscitation of the apparently drowned. This method or any other effort to resuscitate the apparently drowned should be commenced at the earliest possible instant. **No second should be lost,** for it must be borne in mind that **complete submergence for** a period **longer than five minutes usually** has **fatal result.** A maximum of speed consistent with performance of the work at hand is a desideratum.

In the Schaefer method the following steps should be carried out:

1. Remove patient from water and commence without delay, ashore, in boat, on raft, or on board ship;

2. Loosen the collar, and if in warm place strip the chest hurriedly;

3. Roll patient over so that he rests on ventral surface of body;

4. Step astride, and with hands clasped under his abdomen, raise the body and shake thoroughly in effort to expel water from upper respiratory tract and stomach;

5. With patient still face down turn head to one side and wipe out mouth and pharynx with handkerchief or any available fabric; in its absence hurriedly sweep mucus out of pharynx with finger, leaving the face turned to one side;

6. While clearing the mouth draw tongue forward;

7. Extend the arms forcibly above the head leaving them in this

position. Forced extension of the arms places the chest in a state of extreme distention.

FIG. 111.—The Schaefer method of resuscitation of the apparently drowned. Attempting to expel water from naso-pharynx and upper respiratory tract.

If the foregoing instructions have been followed the patient will be lying prone with arms extended well above the head and face turned to one side. The operator should now:

FIG. 112.—Schaefer method. Forcibly extending the upper extremities places the chest in a state of permanent distention.

8. Kneel astride the subject at a level of the iliac crests of the latter, and placing both hands upon the lower posterior part of the

thorax, with thumbs parallel to the spinal column and fingers extending over the lower ribs, should make rhythmic pressure at a rate not

FIG. 113.—The Schaefer method. The operator's hands are placed over the lower ribs posteriorly. A blanket or rolled coat under the epigastrium will make counterpressure.

exceeding fifteen times per minute. This pressure should not be violent but should be exerted upon the hands by the weight of the

FIG. 114.—The Schaefer method. The operator leans forward, throwing the weight of his body upon his hands and without removing his hands returns to the position shown in the preceding figure.

operator merely leaning forward—*not squeezing*. Violence may cause fracture of ribs. (A coat or blanket rolled and placed under patient's

epigastrium will aid in making counterpressure when the thorax is compressed.)

9. If the subject commences to breathe the efforts at resuscitation should be continued, and careful watch should be kept upon the patient's respirations until it is evident that the function has become definitely established;

10. If oxygen inhalations are available, they should be administered at once;

11. Usual treatment of shock should follow;

12. Where there is even remote possibility of resuscitation effort should be continued for four to six hours, since patients apparently

FIG. 115.—The Sylvester method. The operator pulls the arms well over the head.

drowned have commenced to breathe after several hours of persevering effort at resuscitation. *Do not give up too soon.*

The Sylvester method of resuscitation of the apparently drowned is an older method which is more laborious, and usually requires an assistant.

The subject should be shaken and the mouth and nose cleared as described in the Schaefer method. After this the patient is rolled on his back, the tongue is grasped and pulled forward by the assistant who holds it in this position to prevent its falling backward and closing the glottis.

The operator, kneeling at the patient's head, seizes his forearms near the wrists, lifts them up, extending them well above the patient's

head, then brings them down in such manner that the forearms are flexed at the elbow and the lower portion of the chest is compressed by the operator's pressure upon the forearms and chest. This should be repeated about fifteen times per minute.

The following disadvantages are apparent in the Sylvester method:

1. Two persons are constantly necessary for its successful performance, else the glottis may be closed by the tongue falling backward; tying it out with string around tongue and lower jaw is unsatisfactory;

2. The position of the patient is such that any mucus or water accumulating in the pharynx will not be expelled by gravity, but must be wiped out;

FIG. 116.—The Sylvester method. Making compression upon the lower thorax.

3. The work of the operator is so laborious that maintenance of artificial respiration with this method is extremely difficult without frequent reliefs.

The Schaefer method is the method of choice. It effects an exchange of over 50 per cent. of the tidal air, or about 225 c.c. at each respiration.

(*b*) **Mechanical devices** for the maintenance of artificial respiration have been placed on the market. They range from the pulmotor to the plumber's plunger. My experience, observation and information lead to the belief that the employment of such apparatus seldom is efficacious if it is not actually harmful.

Great danger attends the use of apparatus which induces a partial

vacuum during the expiratory stage. Recoveries do not follow the use of apparatus for maintaining artificial respiration after the subject ceases to breathe spontaneously; consequently, manual effort really is all that is required to supplement Nature's enfeebled performance of function.

Perhaps the best of all apparatus used in efforts to resuscitate the apparently drowned is the **lung motor.** It may be used whenever artificial respiration should be employed.

The apparatus enables the administration of air alone or a mixture of air and oxygen, the latter being generated in an apparatus specially devised for the purpose.

The lung motor has certain perishable (rubber) parts, and like all other apparatus for keeping up artificial respiration, requires constant inspection as to its efficiency.

Too commonly apparatus of this character, complicated, requiring skilled operator, and composed in part of perishable (rubber) parts, is so far away from the point where it is needed that manual efforts must be resorted to, and by the time the mechanical apparatus can be available the issue of life or death already has been settled.

Persevering employment of the Schaefer method (especially if oxygen inhalations are administered simultaneously) will accomplish all that may be hoped for in the use of mechanical devices. It may be instituted at once. It is immediately available. If respiration spontaneously exists or has become established by manual effort, it is unwise to resort to the doubtful expedient of employing apparatus even if it is at hand.

If spontaneous respiration is occurring the patient should be watched for several hours until he is thoroughly conscious, to insure that breathing is continued. The usual treatment for shock should be employed; namely, stimulants and applications of heat.

CHAPTER XXII

MARINE ANIMAL LIFE DANGEROUS TO MAN

Animal life in the water may prove a menace to man. Authentic instances of injury to naval personnel have been reported as result of bites believed to have been those of man-eating sharks.

The reports of activity of a man-eating shark along the Atlantic Coast during the summer of 1916 have been chronicled, especially on the New Jersey Coast.

The reason for this is not apparent. Since sharks are fond of garbage it seems probable that the decrease in the number of trans-Atlantic ships lessened their food supply, and this individual sought food near the big cities along the coast.

Fish may be harmful to man as result of:

I. Ingestion of flesh containing products poisonous to man;

II. Bites or stings by venomous fish;

III. Grand trauma, *e.g.*, shark bite or powerful blow by the tail of large fish;

IV. Postmortem decomposition.

I. Ingestion of Flesh Containing Products Poisonous to Man.—Fish living in coral reefs often are dangerous and should not be eaten except on advice of natives, and after feeding tests on dogs if possible. A fish found in Japan called fugu is very poisonous and Scheube states that the natives often use it in committing suicide. This fish belongs to the genus *Tetraodon*. The poison is found in the ovaries and testicles. The symptoms appear rapidly after eating the fish or the roe, and consist of nausea, abdominal pains, severe headache and collapse. Death may occur within a few hours as result of paralysis, cardiac or respiratory.

The Muki-Muki or *Tetraodon hispidus* is poisonous and is referred to in Hawaii as the "death fish."

The following are important species which are poisonous:

Tetraodon hispidus	*Spheroides rubripes*
Tetraodon lunaris	*Lagocephalus lævigatus*
Spheroides stictonotus	*Spheroides chrysops*
Spheroides vermicularis	*Canthigaster rivulatus*
Spheroides hypselogencis	*Spheroides pardalis*

Symptoms following ingestion of the flesh of fish should be immediately treated by emptying the stomach and stimulation.

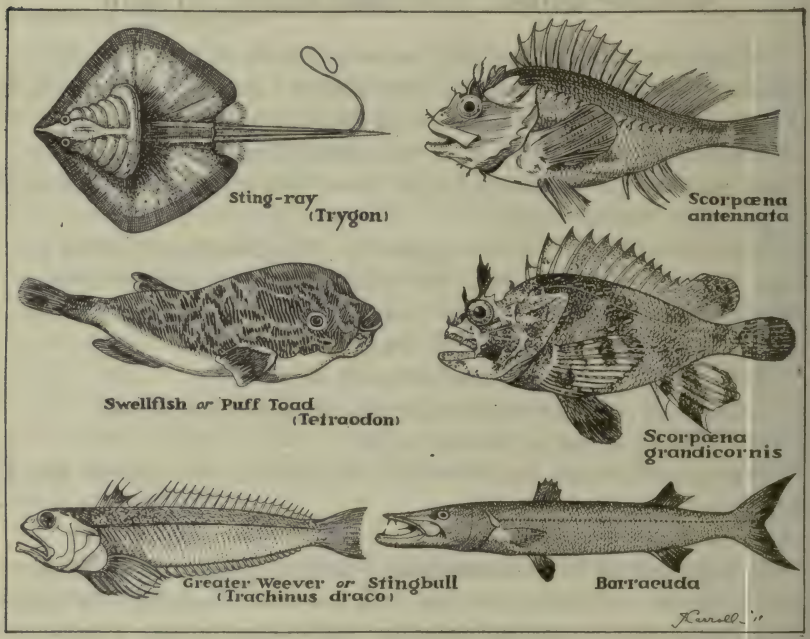


FIG. 117.—Poisonous fishes. The sting-ray or trygon belongs to the *Dasybatidæ*. (*From Stitt.*)

Occasionally fish are brought up from considerable depth, for instance several hundred fathoms. These animals are repulsive in appearance, are swollen as result of release of pressure at great depth, have large heads from which their bodies taper to a comparatively small point, the end of which is terminated by the characteristic fish tail. The flesh of these animals is translucent and their general repulsive appearance causes them to be uninviting as food stuff.

Surgeon W. W. Hargrave, U. S. Navy, reports that barracuda, goatfish and yellowjack are believed to be poisonous by the natives of Grand Cayman, B. W. I. Symptoms appear early, the first effect being upon the sensory nervous system. Tingling of fingers and nose, itching or pricking of the skin appear and are followed by violent gastro-intestinal symptoms. Other symptoms are prostration, general body pain, headache, lacrimation, photophobia, blurred vision, and constant desire to void urine. The natives regard cases in which there is no vomiting as very serious, and think that the earlier the vomiting the better the prognosis. The duration of the incapacity varies in some cases, extending over considerable periods, sometimes even weeks.

Oudard has reported the occurrence of 70 cases of poisoning resulting from eating the fish in China called *Sciæna sina*. (*Archives De Medicine Navale*, No. 7, 1909.)

This fish is not regarded as poisonous. It is possible that it becomes so at certain periods during the development of organs of generation. The poisoned persons suffered violent gastro-intestinal symptoms and shock with dilated pupils.

In China and some other parts of the world the custom of poisoning fish has been in vogue. *Croton tiglium* and other poisons have been used. There is a possibility that these fish had been poisoned instead of being caught by the usual methods employed by fishermen.

Mollusks and crustaceans may cause poisoning (see "Oysters" and "Clams").

II. Bites or Stings.—The following is a classification of venomous fish:

(*a*) Those whose bite is poisonous;
(*b*) Those having poison glands which connect with spines;
(*c*) Those producing a poison in their skin glands.

(*a*) The bite of any fish may result in dangerous infection as result of presence of infecting organisms, but these must be differentiated from **fish possessing venom apparatus** which poisons when the fish bites. The genus *Muræna*, of which there are more than a hundred species, may be taken as a type of this class. Severe bites may be inflicted by their strong teeth.

These fish have a poison gland just above the palate, mucous membrane covering the gland and the three or four erectile teeth which are connected with the poison gland.

When a bite is inflicted the poison flows down the teeth into the wound. The *Muræna* are found in tropical and sub-tropical waters.

(*b*) **Those Having Poison Glands Which Connect with Spines.**—Bottard's classification divides this class into three groups.

1. *Fish whose poison apparatus is entirely closed.* Rupture of a membrane is necessary before the poison can escape.

Synanceia verrucosa
Plotosus anguillaris.

These fish are found widely distributed in the waters of the tropical Pacific. In Tahiti the natives fear them. *Synanceia* is a type. The many species of *Synanceia* possess dorsal fins, the spines of which connect with pisoon glands.

When the fish is struck by human skin the spines enter the flesh and the poison enters the wound.

Excruciating pain follows with swelling. If the amount of poison is sufficient, death may occur. Septicemia or sloughing may occur.

2. *Fish whose poison apparatus is partly closed.*

Thalassophryne reticulata
Thalassophryne maculosa.

Thalassophryne reticulata, Günther and *T. maculosa, Günther,* the former from Panama and the latter from the Gulf of Bahia, are typical of this subdivision.

Their poison apparatus consists of two parts: (*a*) a hollow barb and poison gland on the gill covers; and (*b*) a similar apparatus on the dorsal aspect of the fish near the head.

The hollow barbs connect with the poison glands and when the barb sinks into the flesh of a victim the poison flows out of the channel into the wound. The nature of the venom is unknown.

Calmette regards the poison apparatus of *Opsanus tau* of North American waters and *Marcgravia grunniens* found in the Antilles, as identical with that of *Thalassophryne.*

3. *Fish having poison apparatus more or less directly communicating with the exterior.*

Trachinus draco
Trachinus radiatus
Trachinus araneus
Myoxocephalus scorpius
Myoxocephalus bubalis
Cottus gobio
Callionymus lyra
Scorpæna porcus
Scorpæna scrofa
Pelor filamentosum
Uranoscopus scaber
Trigla hirundo.

Trachinus draco lives in the sand, is apt to come in contact with swimmers and is a type of this group. It has a barb on the operculum and one on the dorsal fin. Each of these is grooved and connected with its poison gland. A membrane covers the groove upon the barb, thus making a canal through which the poison enters when the barb pierces the flesh of an animal.

The poison causes extreme pain, numbness, swelling, sense of suffocation, and in some cases syncope, delirium and death. It resembles snake venom in its effects. Dunbar-Brunton states the flesh of this group is edible.

(*c*) Of the *Elasmobranchii* only two cause poisonous symptoms; namely, the *Dasybatidæ* or **sting ray,** and the *Myliobatidæ* or **eagle ray.** Both of these have a barb attached to the tail and produce a poisoned wound when they sting. They have no poison gland and it is believed that the venom is secreted by the glands of the skin. Their sting is painful and causes much swelling. In some cases abscess and sloughing occur.

The sting of these fishes does not usually cause death. The rays are found in tropical and sub-tropical waters. Those of the northern coast of South America, especially at the mouth of the Orinoco River, are said to be unusually venomous and to be capable of producing death in forty-eight hours.

The treatment of injuries produced by poisonous fishes resembles that of snake bite, namely:

(*a*) Prevent entrance of poison into the general circulation;
(*b*) Neutralize the poison locally if possible;
(*c*) Stimulate and treat symptomatically.

Those swimming in shoal water in the sub-tropical and tropical climates are liable to injury by contact with **sea urchins** (**echinoderms**). These animals are covered with spikes sometimes several inches long. The spikes are calcareous, very frangible, and coated with a transparent viscous substance. They are very sharp-pointed and readily enter the skin of the swimmer who comes into contact with them. Their brittleness causes them to break, leaving a calcareous mass with its proteid covering in the flesh of the swimmer.

While the writer was serving on the Bancroft in Porto Rico a swimming party came in contact with a bed of these animals as they were growing in shoal water on the beach. Several men were injured. The worst injury was that of an individual

who, endeavoring to avoid one sea urchin, fell into a collection of them, wallowing as would a horse. He suffered much pain during the process of removal of the many spines which had entered his back and legs and was incapacitated for duty for a number of days as result of his accident.

Medical Inspector W. S. Pugh, U. S. N., reports a case of injury resulting from contact with a sea urchin near Corinto in Nicaragua.

The man was bathing in the surf, felt a prick in the sole of his left foot, and thought he had stepped on a shell. In a few moments he became giddy, was conscious of swelling of face and eyelids, and came out of the water, but was so weak that he could not walk unaided.

When examined his face was found to be dark red and swollen, pulse very irritable, varying from 70 to 120 in a very short period of time. There was anæsthesia of the anterior surfaces of legs and arms with almost complete motor paralysis of both legs. The plantar surfaces of the left foot showed six small punctures from which were extracted the spines of a sea urchin. These were so brittle that they had to be removed in pieces.

The nervous and vasomotor symptoms cleared in about twenty-four hours, and the wounds were healed in five days.

Jelly-fish, "sea nettles" (*Trachymedusæ*), are disagreeable swimming companions. Along the northern coasts of the United States contact with jelly-fish commonly results in the production of erythematous welts at the point of contact, with considerable burning and pain, but constitutional symptoms are seldom observed, although they do appear occasionally. It seems probable that the size of the dose of poison from the jelly-fish has much to do with the constitutional effect, as fishermen and other adults do not experience severe constitutional effects, in part because the dose is not sufficiently large.

It will be observed that the fatal case mentioned below was that of a fourteen-year-old Filipino boy. The adult Filipino is small and of course this boy had not a large body to be influenced by the dose of poison which he received. In the case of Miss Y, also mentioned below, the body weight was not over 100 pounds.

The variety or varieties of jelly-fish producing poisonous effects are unknown.

Miss Y, while bathing at Piney Point, Md., in 1916, was stung on the left cheek by a jelly-fish. There was marked prostration which compelled her to go to bed for several hours. She states that she felt "all in." Beyond the depression nothing was noticed except the pain and swelling of the left cheek and eye.

In the tropics jelly-fish (*Trachymedusæ*) cause serious symptoms in adults.

Surgeon E. H. H. Old, U. S. Navy, has reported several cases collected by him of which the following is typical:

A hospital apprentice at Canacao, Philippine Islands, in June, 1907, while bathing off the hospital wharf, was stung by a jelly-fish. He said that he was some distance from the landing, and, as soon as he felt the sting, he turned back to the wharf; that on his way he felt some pain across his back, but thought it was due to swimming. On his way up to the hospital he began to feel bad and sat down for a little while. When he reached the hospital, about thirty minutes after he had been stung, he became prostrated and had to be carried to bed.

On arrival I found a slightly raised, vesiculated, red area over the left biceps muscle. This "wept" like eczema. The patient was throwing himself around the bed and coughing almost incessantly, expectorating a thin mucus. He complained of nausea but did not vomit. His face was congested and anxious. He wept at intervals, a stream of tears flowing down his face. His nose was occluded as in a bad case of coryza and from it a thin mucus was discharging. He complained of pain in his head and of marked pain in the lumbar region. He expressed much anxiety as to his condition and exclaimed now and then; "I don't know why, but I've lost all my nerve." His temperature was 100.2°F.; pulse 100, strong and full. Examination of blood and urine showed nothing abnormal.

Medical Director C. P. Kindleberger, U. S. Navy, reported a fatal case resulting from sting on the right forearm in case of a Filipino boy about fourteen years of age.

Symptoms of jelly-fish poisoning appear to be erythematous welts, pain, short hacking cough, rapid respiration, thin mucoid expectoration, marked coryza, and lacrimation with rapid prostration, congested face, and great anxiety on the part of the patient concerning the outcome.

As the prostration comes on very rapidly the person should get out of the water immediately after being stung by a jelly-fish, before the depression becomes so great that drowning may result from inability to get to a point of safety.

The **Portuguese man-of-war,** *Physalia pelagica*, causes poisoning and fever at times. Le Dantec states that the natives of Columbia use *Physalia* as a poison. The animal is dried, pulverized, and used for criminal purposes occasionally. In Guadeloupe the farmers use this same powder for poisoning rats and similar harmful animals.

Certain of the *Zoantharia* or *sea anemones* cause urticarial symptoms upon contact with human skin, a do the millepore coral polyps.

It is probable that the skin may be protected from stings of jelly-

fish and coral polyps by anointing it with oil. This protects against the sea anemone.

III. Grand Trauma.—Sharks attack swimmers probably less commonly than is generally supposed. There are several species of sharks. *Carcharodon carcharias*, or the "man-eating shark," is the only species which is believed to attack man. It is the so-called "white shark" of the tropics and grows to a length of thirty or forty feet. In tropical and sub-tropical waters where sharks are very numerous the opinion has been expressed to the writer that they almost never attack uninjured persons, but are very apt to attack immediately persons who may be injured and bleeding.

FIG. 118.—Fatal shark bite reported by Surgeon Prioleau, U. S. N.

The late Mr. A. B. Alexander, Chief of Division of Statistics, of the United States Fish Commission, expressed a similar belief to me.

Surgeon P. F. Prioleau, U. S. Navy, has reported a fatal case of shark bite as follows:

The U. S. S. Dale at the time of the accident was anchored in Canacao Bay, P. I. About 5 : 00 p.m., May 31, 1917, E. E., water tender, attached to the U. S. S. Dale, started out for a long swim, accompanied by one of his shipmates. E. E. was a most excellent swimmer, and, after a time, his companion becoming tired and not wishing to go further left him, and he continued to swim alone in the direction of the open bay. About 5 : 45 p.m. a seaman of the U. S. S. Monterey happened to notice E. E., who was then some 200 yards from the ship, fall suddenly on his back and then give two or three violent strokes in the water. At the same time the observer saw a shark in close proximity to the bather. It was not hard to conjecture that some accident had occurred, and a boat was rapidly lowered and rushed

to the vicinity where the man had last been seen. The body was recovered, but it was evident from the extensiveness of the wound that the man was dead. He was then taken to the morgue of the United States Naval Hospital, Canacao, P. I.

Nearly the entire abdominal cavity had been torn away. Indeed, the wound extended from the ensiform cartilage nearly to the brim of the pelvis. Laterally, from the right mid-axillary line to the left mid-axillary line. The stomach, the small and large intestine, with the exception of a few feet, most of the liver and bladder, half of the left kidney and all of the large abdominal blood-vessels were removed. The illustration shows the wound as it appeared a few hours after the accident. A portion of the ribs had been taken out with the nicety of a costotome. Some of the skin along the edges of the wound was in ribbons and bore the imprint of the monster's teeth.

Medical Director Middleton S. Elliot, U. S. Navy, has reported from the U. S. S. Annapolis in 1901 the following case:

A gunner's mate, third class, while bathing in the harbor of Iloilo, P. I., on June 24, was bitten by a shark, the left leg being torn away to the knee. The man had gone ashore with a firing party at 1 : 00 p.m. and about two hours later went in swimming. While about 30 feet from the shore, in a depth of water of 10 or 12 feet, he was heard to give a cry and was seen to disappear for a few moments; when he arose to the surface he swam to the dingey 10 feet away and was helped into the boat. It was seen that the left leg was gone. A tourniquet, improvised of a silver match box and handkerchief, was immediately applied by one of the men and the dingey started off to the ship, which was distant about 2 miles. When the boat reached the ship, the medical officer being absent, Assistant Surgeon Jacob Stepp, U. S. Navy, was summoned from the Isla de Luzon and a circular amputation was performed, the lower third of the femur being removed. Subsequent surgical work was required, but recovery resulted.

The wound was peculiar, the thigh having been grasped about 4 inches above the knee joint, stripped down to the bone and the leg torn away at the joint, thus leaving the lower extremity of the femur free from all tissue. He stated that he remembered nothing except that he felt something suddenly seize his leg and draw him down. When seized, he evidently thrust his hand down in his efforts to free himself and caught his fingers in the shark's mouth, as on the thumb and index-finger of his left hand were two small triangular wounds.

These authentic instances of shark bite have occurred in the naval service during the past sixteen years, and are quoted in support of recommendation that shark nets be spread at stations where there is much swimming in waters infested with sharks.

Since sharks tend to avoid shoal water swimmers may have some protection by staying in shallow water. The above-mentioned fatalities should not deter the practice of swimming, since the deaths from shark bite in the naval service during the period above mentioned are

negligible when compared with the number of deaths from drowning during a corresponding period.

IV. Postmortem Decomposition.—The flesh of fish decomposes rapidly, especially in the tropics, and may become infected with the bacillus of Gärtner or with *Bacillus paratyphosus B*, (*Schotmüller*). These organisms produce marked gastro-intestinal irritation, choleraic in character, with profound depression and sometimes collapse and death.

Treatment.—Cases of this character should receive castor oil, followed by treatment for shock.

While on a visit to Mbau in the Fiji Islands I was called upon immediately after my arrival to treat a woman moribund with fish poisoning. She had eaten recently-caught fish of questionable quality about twenty-four hours previously. She was in profound collapse with all the usual symptoms of fish poisoning, and died within forty minutes after she was seen. Immediately after her death I left the house, but shortly was summoned to return. Upon my arrival at the house I was presented with the woven grass mat upon which the women died as a token of great respect and appreciation.

Her case is illustrative of what may occur in connection with fresh fish in the tropics. The fish had been out of water in the tropical temperature a longer time than was safe, had the fish been wholesome otherwise. There was a doubt, however, as to the innocuous quality of that kind of fish even when fresh.

CHAPTER XXIII

INSECTS WHICH MAY PROVE DANGEROUS TO MAN

Cockroaches.—The **roaches** belong to a very large family, the *Blattidæ*. They flourish in warm countries. On shipboard commonly they are very troublesome. The heat and moisture give favorable conditions for their development.

Two species almost never occur in the same house. They appear to be antagonistic to each other. The species infesting ships and houses are dark brown or dark colored. The color aids in their well-known

FIG. 119.—The German roach (*Blattella germanica*; stages *a* to *d* show development up to *e*, the adult; *f*, adult female with egg case; *g*, egg case enlarged about six times; *h*, adult with wings spread. All natural size except *g*. (*From Riley.*) This is the roach commonly found aboard ship.

concealment during daylight. The males have two pairs of wings, the outer being somewhat chitinous, the other membranous. The legs have bristles or spines and are long and strong. The mouth parts are powerful, enabling the eating of hard substances, for instance, leather, woolens, book bindings, etc.

The roaches most commonly found aboard ship are the **German cockroaches,** which are the vilest of a vile family. They thrive around galleys, pantries, or other places where the temperature is warm, concealing themselves in the day and coming out at night to feed. Aboard ship they frequently destroy considerable food stuff, and if permitted

to develop in numbers, ruin foods to which they have had access. The disagreeable roachy odor comes from a dark fluid exuded from the mouth and also from the excrement. The eggs are laid in a hard capsule, which almost fills the body of the female before oviposition. Each capsule contains many eggs. When the young are hatched they pass through several molts and it is said that four or five years are necessary for an individual to reach its full growth.

Hummel has shown that the German cockroach may attain full growth within six months under favorable conditions. The German cockroach is sometimes called the Croton bug, because attention was first attracted to it in this country as result of extension of the Croton system of water works in New York City. This pest may be carried long distances through water pipes without injury. Cockroaches hide and hibernate during winter.

Remedies. *Poisons. Sodium Fluoride.*—Of the poisons sodium fluoride is most effective. It should be dusted into the runways or hiding places of the roaches. It cannot be depended upon if used in the presence of moisture. The surface must be dry.

Phosphorus.—A sweetened flour paste containing 2 per cent. of phosphorus is a very useful poison.

Sulphur.—Mudd states that flowers of sulphur dusted along their runways is a very effective repellent.

Fumigants.—See chapter on disinfection.

Aboard ship the **jet from the steam hose** will often prove an effective means of exterminating cockroaches in cracks where mechanical cleaning appears impracticable.

Traps.—As cockroaches feed at night an extremely efficient trap for them may be used by greasing with rancid butter the inner surfaces of the sides of bread pans about 3 inches in depth. The butter attracts the insects by its odor and once in the pan they cannot crawl out over the greased surface nor can they fly out. Large numbers can be trapped thus and killed by pouring boiling water into the pan.

As cockroaches crawl almost everywhere and grovel in filth they readily may spread filth- and sputum-borne diseases by infecting food and water.

Lice.—The close contact of individuals on board ship predisposes to ready transmission of **lice** from one person to another. However, the facilities for bathing and for washing clothes are so good that lice are little seen among the enlisted men of the Navy.

Phthirius pubis (*Pediculus pubis*), the **crab louse,** is oftenest seen. During twenty-one years of service the writer does not remember to have seen a case of infestation of an enlisted man with *Pediculus vestimenti* (*corporis*). An occasional instance of infestation with *Pediculus humanus* (*capitis*) is seen.

Forces on shore having poor or no facilities for bathing and washing, suffer much from lice, and when they come aboard ship may readily spread lice among a naval crew serving on transport duty. Lice have

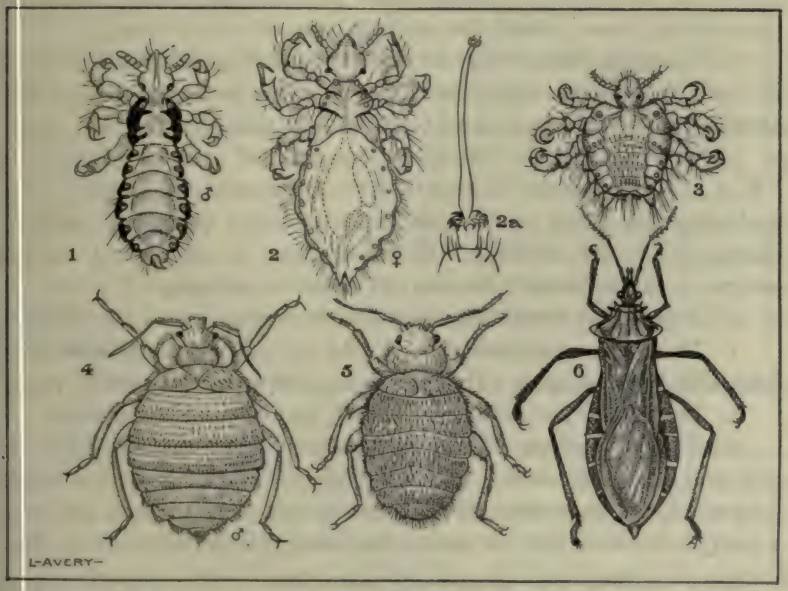


FIG. 120.—Siphunculata and Rhynchota. 1. *Pediculus capitis*. 2. *Pediculus vestimenti*. 2a. Protruded rostrum of *Pediculus*. 3. *Phthirius pubis*. 4. *Acanthia lectularia*. 5. *A. rotundata*. 6. *Conorhinus megistus*. (*From Stitt.*)

been proved to transmit typhus fever and relapsing fever. Their rôle in transmission of other infectious diseases is not known. They have been found to harbor *B. lepræ* when living on a leprous host.

Pediculus Vestimenti (or Pediculus Corporis).—The body louse is about 3 × 1.5 mm. in size. The female lays from three to eight eggs daily during the entire period of adult life.

These eggs are yellowish brown in color, small, and almost pear-shaped. They are covered by a chitinous shell, and firmly attached to the underclothing by a cement.

The eggs hatch in ten days and undergo no metamorphosis. They attain sexual maturity in twelve days.

Head-gear, clothing, shoes, bedding, furniture, carpets and hangings may become infested by the body louse. It lives on the clothing, especially in the creases, except when sucking blood, which it does twice a day. It carries typhus, and may carry relapsing fever. Riggs considered it a carrier of enteric fever. (See Trench Fever.)

Eradication.—(*a*) When the clothing will not be injured by steam it should be subjected to steam under pressure for twenty minutes if practicable; if not, boiled for one-half hour.

(*b*) Clothing which would be injured by boiling should be immersed in coal oil, gasolene, petrol or benzene. This is the best method for treating woolen garments and blankets. It kills both lice and eggs.

(*c*) Peacock regards "N. C. I." as the best agent for killing lice. "N. C. I." is composed of naphthalene 96 per cent., creosote 2 per cent. and iodoform 2 per cent. One ounce per man per week should be dusted inside the clothing. If this is done at night and the man wraps up in his blanket the lice are killed by morning.

(*d*) Elbert and Soulima recommend for troops one of the following:

1. Thirty-five per cent. cresol and 65 per cent. naphtha soap. This kills lice and eggs. The odor acts as repellent for several weeks.

2. Thirty-five per cent. xylol and 65 per cent. naphtha soap.

(*e*) The hot ironing of seams of garments once a week kills adult lice and also any newly hatched ones. If in addition to ironing "vermijelli" (crude mineral oil 9 parts, soft soap 5 parts, and water 1 part) is smeared into the seams the young will be killed as hatched.

Moore concludes after careful study that a mixture containing talc 20 grams, creosote 1 c.c., sulphur ½ gram is six times more effective than "N. C. I.," is less irritating to the skin and is more readily applied. He regards unfavorably the impregnation of underwear and recommends the use of a cheese cloth pajama suit impregnated with the insecticide and worn outside the underclothing.

He also recommends chlorpicrin or nitrochloroform which is volatile, penetrating and very toxic.

Both lice and eggs are killed in thirty minutes if clothing is placed in a closed metal chamber (*e.g.*, a galvanized iron can) and chlorpicrin sprinkled through the garments.

Dry heat 140°C. kills lice and eggs in 30 minutes.

Dry heat 160°C. kills lice and eggs in 10 to 15 minutes.

(*f*) Gunn finds a solution of sulphur 1 per cent. and naphthalene 1 per cent. in benzol most effective. Garments are immersed in this solu-

tion. The benzol evaporates and leaves the fabric impregnated with sulphur and naphthalene, which prove prophylactic and insecticidal against pediculi and against *Acarus scabei* also. He says, "One man showed me a shirt with over 200 dead lice on it after using the solution."

(*g*) Turpentine kills lice and nits.

A soap solution containing 10 per cent. tetrachlorethane or 2 per cent. trichlorethylene will rid garments of lice in one-half hour if they are soaked in the solution at a temperature of 54°F.

The phenol disinfectants are unsatisfactory.

Phthirius pubis (**Pediculus pubis**) or the **"crab" louse.**—This louse is that most commonly seen in the naval service. It infests the pubic hair. In hirsute individuals it may spread upon abdomen, chest and other hairy parts. I have seen a case in which this occurred, nits being found in the eyebrows.

The jug-shaped female is about $\frac{1}{25}$ inch long, lays a dozen eggs, and in a week the young are hatched. The crab louse clings tenaciously to the skin by means of the powerful hooks on the second and third pairs of legs, and is removed with difficulty by the aid of forceps.

Extermination.—This is best accomplished by:

(*a*) Treating the clothing by one of the methods described under *P. vestimenti.*

(*b*) Thorough washing of the pubic region and perineum with soap and water, after which the hairy parts should be treated with 10 per cent. acetic acid to remove the nits, and blue ointment should be generously rubbed into the skin and hair.

(*c*) Kerosene may be applied locally. If this is done the clothing should be left off until the oil is evaporated. The writer has seen a self-treated case blistered as result of putting on the clothing too soon after the application.

(*d*) Turpentine may be used locally but cautiously to prevent blistering.

(*e*) It may be necessary to shave or clip short the pubic hair in order to remove the nits, which usually are attached to the hair some distance from the skin.

(*f*) As the nits hatch out in about six days a second insecticidal treatment should be employed one week from the first.

Too commonly treatment is directed solely at the insects. The clothing should be thoroughly treated also. The writer believes that

the use of kerosene on water-closet seats once weekly is good practice if the seats cannot be treated with a steam hose. White enamel painted seats of hard wood are recommended.

Pediculus Humanus (P. Capitis).—The female lays about fifty eggs. These hatch in a week, mature rapidly and deposit eggs in three weeks. "They vary in color according to the color of the hair of the host." (Stitt.)

Extermination.—This is easily accomplished in military service.

The hair may be clipped or shaved from the head to remove the nits. Then turpentine or kerosene may be applied to the scalp carefully. In cases where the hair may not be cut short the application of 10 per cent. acetic acid will loosen the nits, which may be removed by use of a fine-toothed comb.

The head-gear should not be forgotten, but should be carefully treated with gasolene, kerosene, or turpentine.

The Bed Bug.—The bed bug (*Acanthia lectularia*) may gain entrance to a ship or barracks in the baggage of the men, in baskets of laundry, or upon the clothing of those returning from liberty spent in houses infested with these "crimson ramblers." I saw bed bugs upon captured accoutrements which were brought aboard the U. S. S. North Dakota by our men who took over the fortress at Vera Cruz in 1914. The bed bug belongs to the Hemiptera, has a piercing and sucking beak, and has rudimentary wings or pads. The adult is flattened, oval and mahogany red in color, the abdomen being tinged with black. After feeding the body assumes a bright color from the blood which it has taken, is elongated and distended. The absence of wings in the bed bug is a blessing to man. The bed bug possesses a characteristic odor which comes from glands in several parts of the body.

The bed bug normally feeds at night but hunger may drive it to attack voraciously in the daytime. After feeding it leaves the body and conceals itself in its normal hiding place, which commonly is a crack in the wall or under loose wall paper or about the bedstead or in the seams and tufting of the mattress. Their powers of concealment are remarkable. It is said they can go into any crack which will admit the edge of a sheet of writing paper.

The eggs are deposited several times a year in batches of about fifty. Under favorable conditions they hatch in ten days and the yellowish white insects emerge. They pass through five molts before reaching the adult stage.

The bed bug takes one meal between each molt, requiring about five to ten minutes of feeding before becoming filled with blood. Marlatt states that "Young bed bugs obtained from eggs were kept in small sealed vials for several months, remaining active in spite of the fact that they had never taken any nourishment whatever." The insect probably can survive for a year without food.

In residences where the bed bug feeds constantly on the same persons the danger of transmission of disease is comparatively small, but on board ship, in barracks, on trains, and in hotels the probability of disease transmission is considerably increased.

Kala-azar, plague, relapsing fever, and chagas fever have been transmitted by the bed bug. Typhus, leprosy, syphilis, and other diseases, possibly are transmitted by it.

Remedies.—Fumigation with sulphur is best on board ship. It kills both the insects and eggs. Hydrocyanic gas is unsafe. Insect powders are of slight value. Benzene and kerosene injected into cracks are effective. Corrosive sublimate is of value. The writer has used the gasolene torch on board ship with good effect, and where practicable the steam hose is useful.

Flies.—Flies, especially the *common house fly, Musca domestica,* often come aboard ships on the clothing of persons coming aboard, or on marketing and fresh provisions. When the ship lies alongside the dock or is in the dry dock, they may become a pest, owing to their great numbers.

The house fly may be considered as a type.

The eggs are laid in manure of various kinds, and almost any rotting organic matter.

In a group of storerooms on the U. S. S. North Dakota the writer saw many flies large and small, which indicated breeding near by. Careful search discovered a keg of mustard, the top of which had been broken and the surface of the decomposing mustard literally was covered with larvæ and pupæ.

The fresh vegetable lockers are a common breeding place of flies aboard ship. They breed in decomposing vegetables, especially onions, and unless the source of supply of flies is recognized the ship rapidly may become infested with them.

The female fly lays 120 eggs at a time, several females ovipositing in the same spot, so that the eggs are in groups or clusters in crevices in the manure or other material. The maggots hatch within twenty-

four hours, attain full size within four days, and enter the pupal stage. In this resting stage, which lasts from three to ten days, the maggot contracts within its old skin which forms a round case having rounded ends, somewhat resembling the egg pod of the cockroach, but not so flat. The transition from egg to adult fly requires from eight to fifteen days.

When the ship is away from the dock all flies should be killed as soon as possible, and in localities where there are many flies they should be driven off the market boats as the boats approach the ship.

FIG. 121.—Common housefly (*Musca domestica*): Puparium at left; adult next, larva and enlarged parts at right. All enlarged. From circular 71 (by L. O. Howard), Buerau of Entomology, U. S. Department of Agriculture. (*From Stitt's Bacteriology.*)

The vegetable crates and lockers should be covered with tarpaulin to prevent access of flies. During warm weather the vegetables should be culled weekly to prevent fly breeding as well as to remove rotting vegetables.

Animal pets should not be allowed on board as they attract flies.

Decomposing animal and vegetable matter should not be allowed on board ship.

A plague of flies invaded the U. S. S. North Dakota in June, 1915, in the Philadelphia Navy Yard. Through the ventilating system many were introduced into the storerooms and passages and appeared to have starved there, famished through lack of water, or were killed in passing through the ventilating system. Dust pans full of dead flies were swept up. Many living flies were found, showing that the insects may survive passage through the ventilating blowers and ducts.

At this time it was noticed cockroaches disappeared, as if there might be antagonism between flies and roaches.

Remedies.—On board ship all garbage should be thrown overboard or incinerated. If the ship is not alongside the dock flies may be quickly expelled from many compartments, for instance the galley, by permitting the **escape of free steam,** *before a cloud of which they fly desperately in effort to escape.*

Various forms of fly **traps** have been used, having as bait some mixture containing sugar, molasses, or milk. These have proved very effective in catching flies, which may then be killed by submerging the trap in hot water.

Poison baits may be used. A half dram of formalin in an ounce of sweetened water or milk is very effective. The solution should be in shallow dishes in which a crust of bread is placed. Flies may alight upon it to feed. All organic refuse should be destroyed. This step, with the killing of flies and the aid of the wind blowing through the ship, will soon rid her of the insects.

The writer has seen minor offenses punished at the mast by assigning to the offender "extra duty" consisting of delivery of a number of dead flies or roaches. This punishment gave the offender work to do which was in the interest of the health of the ship.

Water closets, galley and butcher shops should be screened against flies aboard ship.

In camps food should be protected from the flies. Kitchen refuse should be promptly burned, the fluid refuse being received into soakage pits where it is impracticable to evaporate it during the incineration of solid refuse.

Latrines should be fly-proof. The tops should be carefully examined each morning to insure that they are tight.

Lelean states that the latrine trenches should be lined with "sacking soaked in heavy oil and stretched on wooden frames" to prevent the escape of fly larvæ which ascend through ordinary sand a distance of 5 or 6 feet. Near the surface of the ground they enter the pupal stage and hatch out young flies. Where it is impracticable to line the trench with sacking, an area 3 feet wide entirely around the trench should be covered with sacking, boards, or heavy tarred paper to prevent the escape upward of the insects. The outer 6 inches of the material used should be turned downward vertically. The newly hatched flies die under this surface being unable to escape. Filled latrines should be covered in the same way.

To prevent fly breeding in manure, borax 0.62 pound and crude calcium borate 0.75 in 3 gallons of water was found effective for each

10 cubic feet of manure. This destroys all maggots and does not inhibit the growth of plants. The cost of this treatment of manure is about one cent per horse per day.

Manure may be spread, dried, and burned.

The **close packing method** is one in which the manure is dumped on hard ground and beaten down with shovels. The pile should not exceed 5 feet high. As this beating tends to form an air-tight surface over the manure pile the temperature resulting from decomposition within the piles may rise to 150°F., and since fly larvæ are killed at a temperature of 115°F. this method is quite effective.

A 1 per cent. solution **sodium arsenite**, to which 25 per cent of sugar has been added, forms an excellent fly poison but is very dangerous. This should be placed in shallow dishes and should be colored to prevent mistaking it for other solutions. Extreme care must be taken to prevent its getting into food or drink.

House flies readily may be transmitters of bacterial diseases as has been shown by the work of Shakespeare, Vaughan and Reed, during the Spanish-American War. After an exhaustive study of the spread of typhoid fever in the training camps they came to the following conclusion:

> We are satisfied that the evidence furnished in our studies, to be detailed later, is sufficient to show beyond reasonable doubt that the most active agents in the spread of typhoid fever in many of the encampments in 1898 were flies. The reasons for coming to this conclusion will be given in detail later, but may be summed up here as follows:
>
> 1. The latrines contained fecal matter specifically infected with typhoid bacillus.
>
> 2. Flies alternately visited and fed upon this infected fecal matter and the food in the mess tents. More than once it happened, when lime had been scattered over the fecal matter in the pits, that flies with their feet covered with lime were seen walking over the food.
>
> 3. Typhoid fever was much less frequent among members of messes who had their tents screened than it was among those who took no such precaution.
>
> 4. Typhoid fever gradually died out in the fall of 1898 in the encampments at Knoxville and Meade with the disappearance of the fly, and this occurred at a time of the year when in civil practice typhoid fever is generally on the increase.

Stomoxys calcitrans or the common stable fly bites viciously. The writer has seen abscess and cellulitis following infection resulting from the bite of this fly. It was held by some to be the transmitter of poliomyelitis. This view has not been confirmed. The measures recommended against *Musca domestica* are effective against the stable fly.

CHAPTER XXIV

THE HOSPITAL SHIP

The presence of the hospital ship with the naval forces in time of peace as well as in time of war has been abundantly justified by the splendid work which has been accomplished.

As the hospital ship is analogous to the hospital on shore it is commanded by a naval medical officer not below the grade of surgeon.

FIG. 122.—U. S. S. Solace, a hospital ship. Note that hospital ships are painted white, have a green band one meter wide all the way around the hull, fly the Geneva Cross flag, and carry a large red cross on the smoke pipe. At night this red cross is illuminated and the ship carries a display of colored lights agreed upon by the civilized nations of the world. An enemy firing upon these unmistakable markings does so wilfully. (*Photograph by Pharmacist Seckelman, U. S. N.*)

In times of peace the naval hospital ship has a personnel of commissioned and enlisted forces of the navy which is concerned with the care and treatment of the sick, and also a naval auxiliary crew with master and officers who are concerned with the navigation of the ship and her material upkeep. The master, under the medical officer in command, has complete control of the naval auxiliary forces on board ship, subject to the regulations covering Naval Auxiliary Forces of the United States Navy.

The naval auxiliary force consists (*a*) **of a deck force,** and (*b*) the

engineer's force. The strength of the auxiliary force varies depending upon the needs of the individual ship, but in general terms consists of a master, sufficient watch officers, chief engineer, his assistants, deck and engine-room forces. In time of war the hospital ship should be manned by a U. S. naval crew.

The construction of a hospital ship is limited by restrictions which are not to be considered on shore. In the hospital on shore extension by pavilions or additions readily may be made. On board ship the entire establishment must be constructed so as to fit within the narrow

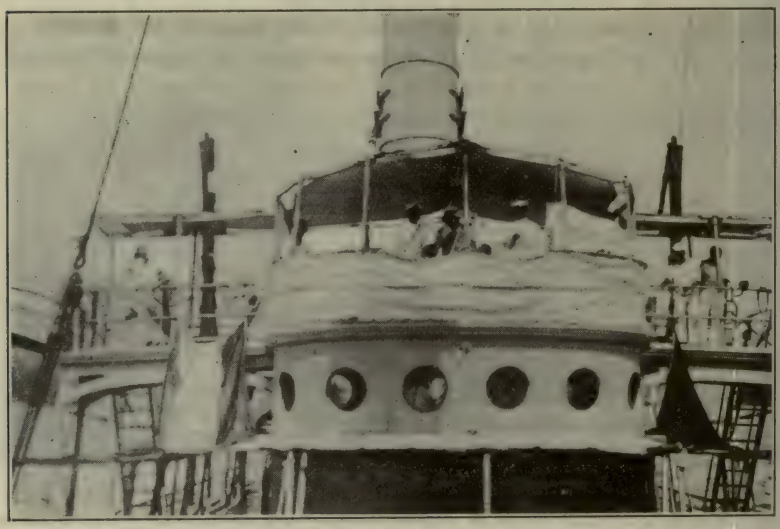


FIG. 123.—The bridge of the Solace. Note the awnings and wind screens for the protection of those standing watch. (*Courtesy of Pharmacist Seckelman, U. S. N.*)

confines of the ship's hull, and conditions which would not be permitted in a hospital on shore must be tolerated on board a hospital ship. For instance: If a hospital ship is 500 feet long its infectious ward must lie within 500 feet of crew quarters, operating room, and medical and surgical wards.

The hospital ship should be so constructed that the wards and operating room may be well above the water-line to enable access of daylight, of fresh air, and to facilitate the handling of sick or injured. The decks and all gangways or passages should be wide to enable the handling and turning of stretchers. Air-ports and ventilating intakes

should be freely supplied. The ship should possess sufficient speed to enable her to keep up with any fleet and should have a distilling plant capable of giving at least 300 gallons of water per day per patient, plus an additional allowance of 50 gallons per capita per day for the

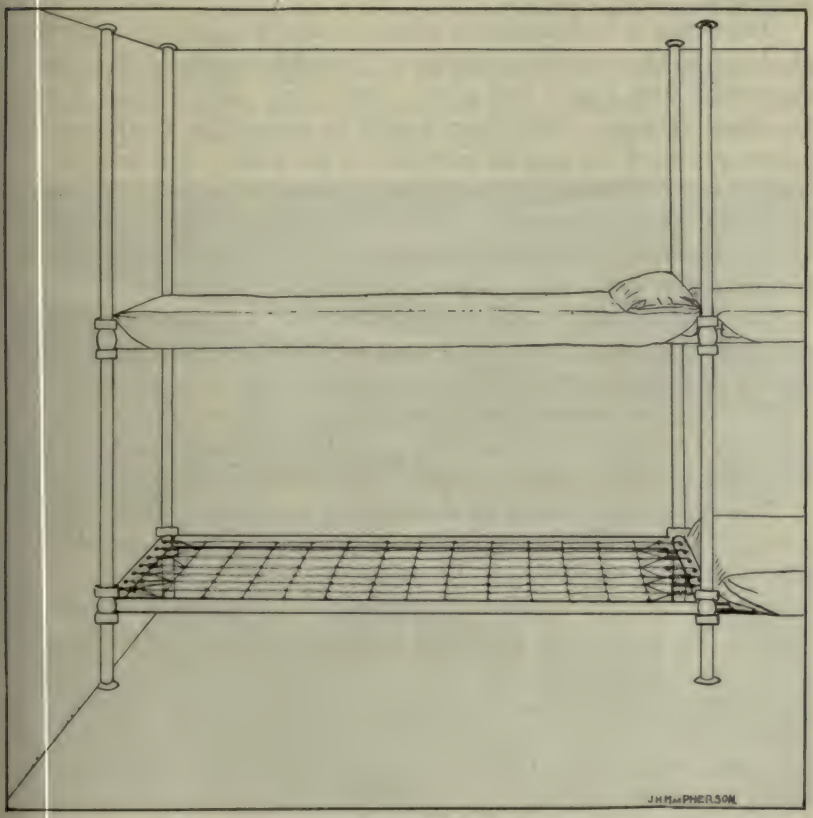


FIG. 124.—Double-deck stationary bunks made of galvanized iron pipe. The springs should grip the pipe, not hook into perforations in the pipe. Bed bugs enter the perforations and breed rapidly in this safe retreat. Sulphur fumigation is required to kill them.

members of the hospital corps and crew. This allowance should be in excess of requirements for feed water. The allowance of fresh water should be unlimited.

The hospital ship should be equipped with **medical and surgical wards** whose passages should be sufficiently wide to permit easy access

of stretcher and ward carriage. A space of 800 cubic feet per person should be allowed, and any deviation from this standard should be in the nature of increase. The deck should be covered with battleship linoleum and should be kept waxed to make it further non-absorbent.

The bunks or beds should be double banked, *i.e.*, one above another as shown in the accompanying cut. Their frames should be made of galvanized iron pipe. The pipes constituting these frames should be closed entirely. Mattresses should be secured to the frames by gripping around the pipe at each end of the bunk. The ends of the bunk frame should not be perforated in order to enable the securing of the bed springs by hooks. The writer has seen the frames of bunks of this character become breeding places for bed bugs in great number, and access to them was rendered extremely difficult.

The hospital ship should be provided with a **dark room in which eye, ear, nose and throat work may be done,** and this department should be equipped with up-to-date apparatus.

The **surgical operating room** should have tiled deck and the operating table secured to the deck. Appropriate instrument tables should likewise be provided and secured to the deck.

The wash room should be immediately attached to the operating room and should have every facility for preparation for aseptic surgery. The sterilizing room should be separate from the operating room in order to limit the amount of wild heat which would be thrown off during the process of sterilizing surgical dressings, instruments, gowns, etc.

The operating room should be located near the middle of the ship in order that the motion may be felt as little as possible. The operating room should be on the same deck with the surgical ward, and between it and the surgical ward should be interposed an anesthetizing room on the one side and a recovery room on the other.

A well-equipped **pathological and bacteriological laboratory** should be installed, capable of doing work of first order. Facilities should be provided on deck aft where guinea pigs, rabbits, mice and sheep may be carried for diagnostic and serological work.

A **mortuary room** should be provided where remains may be autopsied and prepared for shipment.

An **infectious ward** should be provided for the treatment of the various infectious diseases, with bath and water-closet facilities attached

to each unit in the ward, thus enabling the isolation and segregation of patients suffering with the several infectious diseases.

The **venereal ward** should be located so that in case of emergency it may be converted into additional wards for the care of infectious diseases. The venereal ward should be supplied with dressing room and room for treatments.

The **psychopathic ward** should be located near the infectious and venereal wards so that when not occupied by psychopathic cases it may be available in emergency for the treatment of infectious diseases.

FIG. 125.—A ward in a hospital ship. (*Courtesy of Pharmacist Seckelman, U. S. N.*)

The **X-ray room** should be placed as close to the surgical ward as conditions will permit and should be capable of doing work of the first order, since the hospital ship often may act as the analogue of the hospital on shore in a city having a population ranging into the thousands.

An **ice machine** for the manufacture of ice and for refrigeration of cold storage rooms is a necessity. The refrigerating room will

enable the carrying of fresh meats and foods, and the refrigerating plant likewise can be utilized for the cooling of fresh water for the various drinking terminals in the wards and different parts of the ship.

The **refrigerating plant** should include facilities for the preservation of vaccines and sera, and a cold chamber should be arranged in connection with the postmortem room in which bodies may be preserved in cold storage.

The ice machine should be of the dense air type.

The **laundry** should be equipped with tumbler, extractor, and drying tumbler for the laundering of the hospital linen. In conjunction with the laundry a **disinfecting plant** should be established. The linen to be disinfected should be placed in the autoclave in a room outside the laundry. It should be sterilized and withdrawn from the autoclave into the laundry to be washed.

Sufficient number of baths and water closets should be provided.

The hospital ship should have an abundance of **storerooms** in which may be kept drugs, surgical dressings and appliances, at least one field hospital for landing forces, and all apparatus necessary for the care and treatment of sick and wounded human beings. A supply of coffins should be carried.

A well-equipped **dispensary** should be provided.

Galleys, pantries and **storerooms** must be provided. The galleys should be on a deck above the water so that the odors from it may not pervade adjacent compartments.

Lounging or **smoking rooms** should be provided where convalescent officers and enlisted men may spend time out of the wards in bad weather.

Berthing spaces for the ship's complement must be provided as well as storerooms for the equipment, repair, and preservation of the ship.

The hospital ship should be steady and supplied with bilge keels to prevent excessive rolling and should be fast, should be provided with a wireless and other signal apparatus, and should be electrically lighted. She should have wide doors and ports so that stretchers may be carried without difficulty. She should be steam heated with high pressure steam heating system and separate ventilating system until such time as the thermo-ventilating system supplying properly conditioned air has been perfected.

The hospital ship should be supplied with a number of large, **swift motor boats** for ambulance purposes. Life boats should be provided for the total complement. A number of cranes should be provided for the hoisting of sick on board, and large, wide ports should be provided in sufficient number to enable the loading and unloading of several boats on each side of the ship simultaneously. Life preservers should be provided for complement and crew, and should be constantly accessible.

FIG. 126.—Convalescent patients brought on deck in Stokes stretchers on a hospital ship. (*Courtesy of Pharmacist Seckelman, U. S. N.*)

The ship's steaming radius should equal that of any of the ships of the fleet. The hospital ship should be an oil burner in order that dust may be minimized. Her capacity should be about five hundred patients, and all wards should extend entirely across the ship, enabling complete perflation of each ward. Longitudinal bulkheads should not interfere with this feature.

When a hospital ship reaches port and desires to discharge her sick into a hospital on shore, *bed patients should be sent first*, so they may be assigned to beds in the wards.

Ambulant patients then should be sent as these may be shifted to meet conditions if the wards are congested.

If possible the hospital should be given a day's notice of the number and character of the patients it is expected to receive, and the probable hour of their readiness for transfer.

They should be accompanied by an alphabetical list of patients in triplicate and by the hospital ticket, health record, service record, and transfer of pay accounts in each case as provided by U. S. Navy regulations.

CHAPTER XXV

ON THE MARCH

In starting on expeditionary service, either from ship or a base, the medical officer should see that the following classes of men are excluded from those who are to undergo the arduous work incident upon campaign:

(*a*) The too young;

(*b*) The too old;

(*c*) The too fat;

(*d*) All suffering with disease of infectious character;

(*e*) Those having deformed feet, or conditions which would interfere with marching;

(*f*) Those convalescent from disease or suffering any constitutional disorders; and

(*g*) Alcohol and drug addicts.

(*a*) **The Too Young** (Under twenty years of age).—This class being immature is not apt to bear well the strain of the work entailed in marching and carrying a heavy pack. They have lessened resistance to infectious disease, are apt to be rash, to display poor judgment, and are less amenable to the discipline so necessary to successful maintenance of health in campaigning.

(*b*) **The Too Old.**—The men past forty-five years of age have not the recuperative power and the elasticity of tissue which go to make up the most effective human machine. Also they tend to bear the hardship and exposure less easily than they would have done twenty years earlier. They tend toward depression and to lack the buoyancy so necessary to effective work in any undertaking.

(*c*) **The Too Fat.**—The fat man is greatly handicapped. The transport of his bulk requires expenditure of more energy than is necessary for the more efficient lean individual having an equal mass of muscle. The fat individual is less able to perform arduous work, as his muscles tend to have fatty degeneration, and on long march myocardial changes may become manifest and incapacity result.

(*d*) **All Suffering from Disease of Infectious Character.**—Those suffering with disease of infectious character should be excluded, especially those having venereal diseases. It should be remembered that each man who must fall out of the marching column incapacitates not alone his own rifle but those of the persons who must carry and care for him. Those who have been exposed to infectious disease should be left behind. If this is impossible they should be watched closely.

(*e*) **Those Having Deformed Feet, or Conditions Which Would Interfere with Marching.**—For obvious reasons those having flat foot, hammer toe, or any other condition which would interfere with steady marching, should be left behind.

(*f*) **Those Convalescent from Disease or Suffering Any Constitutional Disorders.**—Convalescents and those suffering from constitutional disease or nutritional disorders are not apt to become inured to campaign conditions, but rather tend to fight a losing battle when they undertake to meet conditions which tax the strongest man.

(*g*) **Alcohol and Drug Addicts.**—Alcohol and drug addicts should be left behind. They are physically unfit and are unreliable.

Usually the naval forces operate from the ships as a base and it is seldom contemplated that they work far beyond the range of the ship's guns.

When naval forces operate ashore they are usually landed as infantry, and as such the formation and regulations governing infantry apply to them.

Breaking Camp.—The fires upon the camp site about to be left should be carefully extinguished, latrines, kitchen and sullage pits filled and marked, and the site carefully policed, for this same site soon may be occupied by reinforcements, or those leaving the camp site may return to the same site for camp, either in retreat or in returning to the base.

Beginning the March.—The march should be begun as early as daylight will allow and after an easily assimilable breakfast has been eaten. In the tropics and in summer the march should be stopped at 10 : 00 a.m. and resumed at 4 : 00 p.m., unless it can be completed in the morning by marching for a brief additional period of time. In temperate climates, especially in winter, the day's march should be continuous and concluded before prolonged stop is ordered.

Heat Production.—When marching a gradual development of temperature occurs up to about 100.5° or even to 102°F. Like other

machines, the human being performs work better after warming up. A temperature of 100.5°F. is considered that at which the maximum of efficiency is obtained, although it is not uncommon to find men who have a temperature of 102°F. after finishing a day's march.

Distance to be Covered.—Two and a half miles per hour is a good average rate of progress for troops in "heavy marching order." Obviously this rate will vary with terrain, condition of roads, weather, load to be carried, temperature, and physical condition of the troops, especially of their feet.

A well-seasoned infantry company marching under good conditions will cover 12 to 15 miles daily and maintain this rate. For brief time long distances may be covered, but these spurts, which may be so great as 25 miles in a day, usually cannot be maintained. Large bodies of troops move more slowly than the smaller bodies, and far more discomfort is felt from heat, humidity and dust in the larger bodies of troops than in the smaller.

Where it is possible the men should be transported on cars or trucks in order that the troops may arrive in position in as fresh a state as possible.

Marching at Night.—Marching at night is to be deprecated and should be permitted only in extraordinary circumstances. In the dark men cannot be sure of their footing and accidents are liable to happen. Tired and sleepy men cannot be expected to give the best account of themselves. Early to bed and early to rise should be the policy followed.

Underway.—The march should be begun slowly and a halt of fifteen minutes should be allowed at the end of the first hour, and thereafter a halt of ten minutes should be made at the end of each hour. During these halts the men should unloosen their packs, arrange their accoutrements, change socks if necessary, and answer the calls of nature.

Company officers should be vigilant and assure themselves that the non-commissioned officer to whom the duty has been delegated is strictly enforcing orders concerning disposal of dejecta, all of which should be deposited in a hole dug with an entrenching tool and immediately covered before the march is resumed.

In wet weather it is recommended that troops form circles and sit upon one another's knees (Ford). This procedure has the advantage of keeping the bodies of the men from sitting on wet or muddy ground and the further advantage of conservation of body heat.

Music and singing should be encouraged unless there are good reasons to the contrary.

Hitherto "route step" has been the order in marching long distances, and probably this is best today *for troops which are not well practised in marching.* Experience in the present world war indicates that when the load is properly distributed greater distances can be accomplished by keeping step instead of marching in "route step." This applies to troops well trained in this method of marching.

When preparing to perform heavy physical labor the sensible man discards unnecessary clothing, loosens the collar, rolls up the sleeves and dons garments which enable him to have a maximum freedom of action. In other words he prepares to do heavy work. Marching troops are doing heavy work and should prepare for its performance.

If the weather is warm the men should be permitted to loosen collars, roll up sleeves, or loosen garments which retard heat radiation. Green leaves or a wet handkerchief worn under the head dress will afford protection against the direct rays of the sun.

Bandoliers or other straps which cross the front of the chest should not be allowed, and for the same reason tight fitting garments should not be allowed to interfere with the functions of the heart and lungs by making compression upon the thorax.

The troops should march in column of squads unless the weather is very hot, when column of twos will enable better heat radiation.

In cold or disagreeable weather the men on the outer files should exchange places with those on the inner at frequent and regular intervals. This equalizes the exposure and prevents the men on the flanks of the column from bearing the brunt of cold winds and weather.

Each man carries a load approximating 55 pounds in weight and has most of it on his back, consequently a forward inclination of the body is necessary to maintain balance, and considerable training is necessary to enable marching in this position of load carrying.

Feet.—Naval forces living on board ship and accustomed to the smooth wooden decks on which men frequently go bare foot are at a disadvantage when they are placed on shore in campaigning. Their feet have to be hardened, and they really have to learn to march before long distances can be covered at an average speed without considerable discomfort.

Feet frequently become hot and swollen during the march. If halts are made near running streams much comfort can be had by

removing shoes and putting the feet in cold water for a moment or two, not sufficiently long to macerate epithelium more than is already taking place in sweat-soaked socks. The feet should then be thoroughly dried.

Often it will be found conducive to comfort to exchange socks from one foot to the other. In this way pressure from wrinkles in the sock may be completely prevented, and if this is not possible the exchange will effect removal of the pressure to another skin area, thereby preventing possible blistering. Talcum may be dusted into the socks.

Holes in socks are the most productive causes of blisters. The edges of the holes tend to roll and produce damaging pressure upon subjacent skin areas.

When blisters have formed they should be painted with iodine, drained, dried, and repainted with iodine, then covered with a bit

FIG. 127.—Figure-of-eight strap over the instep prevents blistering resulting from friction of the heel by the counter of the shoe. Note the position of the heel as it is raised from the ground. The dotted outline shows how the heel rises in the shoe. The strap prevents this.

of sterile gauze under adhesive plaster. The gauze should be small in area and consist of only a layer or two.

Shoes should be snugly laced to prevent chafing. A leathern strap forming a figure-of-eight over the instep will prevent the up and down chafing of the loose shoes upon the heels.

Corns should be soaked in a warm, weak, alkaline bath and pared well, following which a daily coat of salicylic acid 30 grains to the dram of flexile collodion should be applied. In a few days the corn may be removed easily after soaking. It is well to paint the surrounding skin with vaseline or some oily preparation in order to limit the effect of the collodion mixture to the area of the corn and to prevent injury to healthy skin.

The socks should be washed at the end of each day's march and dried whenever possible during the night.

Toe nails should receive careful attention. They should be pared squarely across, should be kept well cleaned, and should not be permitted to grow long. Long nails are very apt to cause injury to the skin of the toes with danger of infection. Further, when the great toe nail is permitted to grow longer than it should, soreness is caused at the base of the long nail as result of impinging upon the inner surface of a shoe which is relatively too short. Not uncommonly nails are injured sufficiently to cause their exfoliation and much discomfort.

The **skin of the feet** should be kept clean as possible, thereby lessening infection.

Bromidrosis, or excessive sweating of the feet, may cause much discomfort as well as odor. Relief is obtained by bathing the feet in one of the following solutions, viz., 2 per cent. formalin, alum 5 grains to the ounce, or 1 to 1000 bichloride of mercury.

Tender feet should be bathed, then sponged with alcohol. When practicable elevation of the feet will give relief.

Camp Site.—At times it becomes necessary for a naval medical officer to make recommendation concerning camp site for bluejackets and marines operating ashore.

More commonly these forces will be landing under the protection of their own guns, but may advance inland where the ship no longer can be depended upon for fresh water supply.

If a body of troops is in face of the enemy the best must be made of bad conditions, but if not in face of the enemy, and a camp is to be occupied for so long as forty-eight hours, sanitary considerations should control.

When possible a camp site should be beside a stream which will afford sufficient water supply for the command and animals attached thereto.

For tactical reasons an advancing column may cross a stream before camping beside it.

The camp site should be established on sloping ground. If weather appears threatening it should be remembered that a stream suddenly becoming swollen may compel precipitate abandonment of camp site located too near its banks. The soil should be sandy and preferably covered with grass. This will give a minimum amount of mud in rainy weather. The ground water should stand not less than 12 feet

below the surface. The site should be selected with reference to food, fuel, and water supplies, as well as accessibility. The site should be on the lee side of the hill with reference to prevailing winds in cold weather and should be at or near the top of the hill so as to get the breeze in warm weather. It should be to windward of marshes from which mosquitoes might be blown.

In approaching the camp site a sufficient number of men should be sent in advance of the main body to guard the water supply and to establish latrines and urinals, and have them ready upon the arrival of their comrades. This prevents soil pollution. The line of the latrines should be to leeward of the camp and as far from the kitchens and mess rooms as possible.

To prevent pollution of the water supply a guard should be placed around it, and a fence should be put about it in case a pool or reservoir is being used. If on or near a flowing stream the site chosen for drinking water should be situated above that chosen for watering the animals, and still further down stream should be selected a place where washing may be done.

The picket lines should be to leeward of the camp.

The picket lines should be kept clean of manure to prevent the breeding of flies and where possible they should be burned off with straw saturated with kerosene once each week.

Trench Foot.—Trench foot or "frost-bite" is due to muscle inertia and prolonged exposure to cold. Extremes of cold are not necessary to produce trench foot. It may develop at 40°F. Contact of water with the skin predisposes to it. Any venous stasis predisposes to the trench foot, consequently if leggins, puttees, or boots are too tight the condition is more easily produced. The symptoms resemble preliminary peripheral neuritis, followed by gangrene in severe cases.

Prophylaxis.—Drain trenches or raise level of stance by use of boxes, fagots, boughs, etc. Rub whale oil or grease thoroughly into the skin of the foot and leg. The Indians of Tierra del Fuego rub oil into their skins to prevent heat radiation from skin and to shed water. They wear no clothing. If necessary to stand in water long rubber boots should be worn. Even these, however, become wet on the inside from perspiration. Two pairs of socks should be worn.

Shoes, puttees, and leggins should not interfere with peripheral circulation. When resting the legs should be straightened out and feet elevated. It is believed that the pressure of the "fire-step" in the

trench upon vessels and nerves at the popliteal space may be a predisposing cause. Proper, warm, stimulating nourishment and hot soups should be provided. The individual should not sleep in a "curled up" posture, but with legs and thighs extended to facilitate circulation.

Those exposed to cold should keep in motion in so far as conditions will allow. Medical Director F. L. Pleadwell, U. S. Navy, has seen most gratifying results from injection of oxygen into the frost bitten areas. Gangrene appeared to be prevented in all but three cases observed by him.

Trench Kidney or Trench Nephritis.—This is a condition which is poorly understood. There is reason to believe that it is due to the prolonged exposure incident to hard service and cold, wet stations in the trenches, *i.e.*, that it is merely acute nephritis. There are some who regard it as a specific infectious disease, the cause of which is unknown. Fecal streptococci have been considered the cause.

At one station during the winter of 1916–17 the mortality rate for trench kidney was so high as 4 per cent. The symptoms of the disease are those of nephritis plus marked changes in the lungs. The pulse is usually full and bounding and the temperature varies up to 104°.

Prophylaxis.—Avoid exposure. Practise hygienic living. Since no specific organism is known to cause the disease there appears to be no means to attack the disease from the standpoint of serum therapy or vaccines.

CHAPTER XXVI

MALINGERING

Occasionally a malingerer is found among those who desire to separate themselves from a service which is distasteful to them for various reasons, *e.g.*, homesickness, family trouble, etc.; or those who desire to avoid a disagreeable task; or among the few psychopathic individuals who are encountered in the service. Malingerers may be classified as:

(*a*) Those who willfully exaggerate deformities, or the results of injuries;

(*b*) Those who, without evident anatomical basis, feign disease or produce symptoms by drugs or other agents.

(*a*) The class who **willfully exaggerate** deformities or the result of injuries is a difficult one to handle. The conscientious medical officer often feels chagrined at his inability to demonstrate the malingering which he feels sure is being practised. The writer had an applicant for treatment who had received a fracture of the clavicle years previously. He alleged that he suffered incapacitating pain whenever called upon to perform any manual labor. The condition did not improve under rest and massage. When he was found pitching a baseball game on shore after having been treated that very day for inability to perform his duties it was believed that a case of malingering had been established.

The nervous effects produced as result of some stress frequently lead patients to make claims of unusual suffering. All such cases in which there is demonstrable evidence of injury with deformity are cases which must be treated very carefully to avoid injustice.

(*b*) The **second group** of malingerers is one which taxes the ingenuity and wit of the medical examiner. The writer has seen **feigned epilepsy** in which a fearsome frothing at the mouth was produced with soap very much after the fashion of Kipling's "Sleary."

Persistent vomiting has been found in one case to be due to the swallowing of snuff taken for that purpose.

A man who has general **œdema of an extremity** should be examined stripped. This facilitates accurate diagnosis and precludes possibility of the condition having been produced by a constricting band placed at shoulder or groin to retard return circulation.

In some of the continental European armies individuals desiring to avoid compulsory military service have resorted to **self-mutilation,** such as cutting off fingers. A certain class of men with some medical training have abetted malingerers by **dilating the inguinal canals** with the fingers in order to render them patulous and produce an incapacitating hernia. Others have submitted to the **injection of paraffin** at sites where the tumors would appear to produce an effect which would unfit them for military service.

If there is suspicion of malingering the **temperature** should be carefully taken, the patient being constantly watched. *Friction on the trouser leg, contact with a steam radiator,* or *immersion in warm water* will raise the mercury column in a thermometer so treated. Also the malingerer may have just rinsed his mouth with water, hot or very cold, and corresponding effect will be produced upon the thermometer which is supposed to register his actual temperature. In any case where there is reasonable doubt the individual should be put in bed and kept there on milk diet. If he is sick no better expectant treatment can be practised. If he is well no more disagreeable treatment can be employed than milk diet, recumbent posture, and enforced use of a bedpan. The malingerer recovers rapidly with such treatment.

Diarrhœal and dysenteric symptoms should be carefully inquired into. Occasionally an individual complains of such symptoms to avoid duty. He should be required to use the stool in the sick bay. Inspection has revealed constipation rather than diarrhœa in some cases.

The **bed wetter** is not infrequently encountered. He should be treated with consideration and given medication and instructions looking toward the prevention of his condition. This is a common form of malingering. If malingering is suspected the individual should be called and made to go to the closet once every half hour during the night. This will usually keep his bed dry and cure his symptoms.

Partial or complete blindness is feigned at times. *Partial blindness* may be detected by one of the several methods of employing prisms.

The aid of the eye specialist usually must be invoked since the apparatus is not at hand aboard ship.

The detection of feigned *complete blindness* is far more difficult and depends upon a careful watch of the case. Detection may be accomplished at times by the sudden employment of ruses such as thrusting an object at the eye as if to stick it into the eye. Preparation for pretended operation on the eye for the relief of the condition will bring confession by the patient.

Feigned color blindness is easy of detection by the examiner who is versed in the examination for defective color perception.

Defective hearing in one or both ears may be feigned. A careful watch of a patient if the otoscopic findings are negative will be of value. The clink of a coin dropped behind him is very apt to make the patient look around.

Myalgia is feigned. The energetic treatment of it is usually sufficient to cure the malingerer.

Occasionally a **mental disorder** is feigned. This requires careful study. The individual who is willing to feign mental disease is suffering from mental disorder and the sooner he is discharged from service the better.

Malingerers employ drugs for:

(*a*) Constitutional effect;
(*b*) Local effect.

(*a*) **Purgatives** for producing diarrhœas and opiates for constipating effect have been used. Santonin produces symptoms which cause the patient to appear quite sick and has been taken for this purpose. Numerous other drugs have been employed for the production of constitutional effect with more or less success.

(*b*) The local effect of drugs is manifested by skin **eruptions, vesication,** etc. Croton oil has been used for this purpose as have other vesicants.

The writer attended a negro mess attendant on the U. S. S. Bancroft who endeavored to be sent to the hospital just prior to sailing. He gave certain symptoms referable to the gastro-intsetinal tract and stated that he had **tape worm.** . After appropriate treatment had resulted in negative findings, and the ship was at sea, he confessed to his effort to be sent to a hospital, stating that he feigned tape worm for the purpose.

CHAPTER XXVII

PERSONAL HYGIENE

The personnel of the U. S. Naval forces embraces a narrower field than that which must be considered by the general hygienist. It includes the male sex from ages of sixteen to sixty-four on active service, and to greater age than this among those on the retired list.

However, the *rates of morbidity and mortality published for the United States Navy refer solely to officers and men on the active list; i.e.*, below the age of sixty-four.

These men come from all stations of life, from all sections, and from every environment. They are taken into surroundings different from those to which they are accustomed, and come in contact with physical forces little known to them. Each is a different mental unit, each must be reckoned with separately, and each must also conform to the many rules and regulations which make possible the existence of an organization like the Navy.

Obviously, the habits of the men composing the naval personnel vary. Among the crew of a large ship carrying 800 to 1000 men, or more, we are apt to find the same manifestation of human frailty which would be found among the same number of men of the same class elsewhere.

Contentment and Work.—There is no truer saying than that "the devil always finds work for idle hands to do." Idleness breeds bad habits and excesses. The day's work should be so arranged that the men are kept busy. Indolence affords time for excesses in the use of tobacco, alcohol, morphine, cocaine, or other drugs, excessive venery, or perversion of the generative functions.

Work or amusement should occupy the hours of each day so as to crowd out the tendencies which inevitably come when time hangs heavily on their hands. Weary men should go to rest and sound sleep at the end of a tired day.

Gambling is a frequent accompaniment of the bad habits, and is a breeder of strife, discontent, or dissension.

The **moving picture** show has done much to afford diversion for men attached to the larger ships, and in a big fleet the exchange of films enables the establishment of a circuit which allows a different exhibition almost every night when weather conditions are favorable for spreading the screen on deck.

Theatrical performances by members of the crew often afford considerable diversion to those interested in vaudeville, and no little

FIG. 128.—The crew's reading room on a battleship.

entertainment and amusement results from the rehearsals preliminary to the performances. The theater ship is now an institution in the British Navy.

Boxing and wrestling matches under proper supervision afford desirable diversion. Athletic contests of all sorts are entered into with enthusiasm by the men.

Intership football and baseball matches are of great interest to officers and men, as are the boat races and swimming contests.

After a baseball game on shore between two rival teams the victorious team in

returning to its ship accepts as one of its privileges the right to encircle the ship of the defeated team and rub in the defeat in a very thorough-going manner.

One has only to see the several boats returning to a ship carrying the victorious baseball team with a brass band and enthusiastic rooters, making a complete circle around the ship of the defeated team, to realize how much interest is aroused by these games.

Lectures and concerts also do their part in entertaining men on whose hands time would hang heavily after the day's work is done.

FIG. 129.—Recreation. Note the method of securing the legs of the mess table and stowing it on racks overhead.

Cleanliness.—The medical officer should aid in every way in the effort to enforce personal cleanliness among the men. Most of them will seldom require admonition, but some there are who will tend to revert to habits of filth, established early in life.

Cleanliness promotes comfort, self-respect, improves morale, and tends to reduce animal parasitic disease infection through the skin, as well as bacterial infections through the same route.

Regularity of habit as to meals is guaranteed by the routine of naval life. The same desirable **regularity** concerning **evacuating the bowel** is not guaranteed. The more or less sedentary habit of men on board ship, where the opportunity for physical exercise is limited, tends to produce constipation. All the persons should be urged to be regular and go to stool at a fixed hour daily, even though there be no urgent inclination.

The human animal likes to eat to satisfaction thrice daily. If waste products are retained he must eat less, defecate more, or burst. Defecation is the most satisfactory of the three courses.

Members of the crew should be instructed to **consult the medical officer** if the bowel is not evacuated daily, or at most every forty-eight hours. Cases of appendicitis, intestinal obstruction, fecal impaction and the like thus may be prevented.

Men should be **urged to drink pure water** frequently, especially before breakfast, and to carry or provide pure water for themselves when ashore, if the water on shore is of questionable purity.

During the routine life aboard ship considerable, but not enough, physical exercise is performed. The **"setting up" drill aids** in maintaining good physical tone. It seems desirable that all persons on board ship should take this exercise daily, especially those whose duties keep them between decks, such as storeroom keepers, engineer's force, etc.

The system in common use in the Navy is that adopted from the Swedish system with necessary modifications. This system is most excellent in that it tends toward symmetrical development of the body, and a quick, accurate, coördinated control of the muscles rather than an overdevelopment of special groups for the performance of feats of strength.

Underclothing should be kept clean, and should be washed frequently. Cleanliness of the skin surface may be maintained with the aid of so little as a quart of fresh water for bathing purposes each day. This amount of water will not be satisfactory to those accustomed to a daily bath, but it will suffice to keep the body decently clean. In modern navies it is never found necessary to practise such economy aboard ship. All should bathe and put on clean underwear before going into action in order to lessen probability of infection of wounds.

A **wash basin** with knee or foot control faucet and paper towels should be placed **at each water closet** in order that ordinary cleanliness

may be possible, and as a measure of prevention of spread of disease, *e.g.*, typhoid, gonorrhea, dysentery, etc.

Tooth brushes should be used, and their use enforced in order that the mouths of the men may be kept clean. The use of the tooth brush tends to reduce the bacterial content of the mouth and to render less frequent the serious as well as milder throat infections.

The dangers incident upon the **common use of razor, towel, pipe, comb, brush,** etc., are too apparent to require more than mention.

The **loan of pipes,** cigar-holders, and of partially smoked cigars, as well as of toilet articles and drinking cups, should not occur.

The **loan of clothing** and especially of underclothing should be discouraged, as skin infections, animal or vegetable, thus may be transferred.

Just here a word may be said about the loan of the tobacco bag. Several men are sitting in a group. One man takes out his tobacco bag to roll a cigarette or fill his pipe. His left hand being engaged with the pipe or cigarette, he brings the bag to his mouth, takes the string between his lips and teeth, and pulls on it to close the bag. In so doing the string becomes wet with saliva and the borrower who repeats the performance just described is afforded ample opportunity to contract any disease, the germs of which may be in the saliva.

The use of tobacco is prevalent. It is not believed that indulgence in the moderate use of this drug is especially harmful to the average mature man. Some men are harmed by the moderate use of tobacco and should not indulge in it. Buckets of water may be poured into a large cask which still stands ready to receive more buckets of water, but there comes a time when the addition of one single drop of water will cause overflow from the cask which hitherto has received water by the bucketful. It appears that a similar condition obtains with reference to the ingestion of certain foods and drugs. Their presence is borne by the body without murmur until, just as with the cask, there comes a time of overflow. Many men have used tobacco freely from youth to ripe old age without consciousness of ill effect. Its use in early life is to be deprecated.

Especially pernicious is the cigarette. Its use by young people produces an effect upon the body processes and upon the nervous system and heart which is well known, and which should, so far as possible, be prevented, as it goes far to spoil the clear head, keen eye, and steady

hand. The sale of cigarettes in the ship's canteen has been discontinued by official orders.

Coffee.—Excessive use of coffee is pernicious and should not be permitted. Ingestion of five or six cups of coffee (as is done at times) is harmful.

Alcoholic Beverages.—Abuse of alcoholic beverages is of course encountered. When called upon to pronounce official opinion as to whether a given person is under influence of an alcoholic beverage, one should always *carefully* examine before expressing opinion. If the individual should be tried by court-martial for drunkenness, and the surgeon who has made a superficial examination should be called as a medical witness for the prosecution, the counsel for the defense easily could elicit the statement, "I just looked at him and knew he was drunk." This would invalidate the testimony of the medical witness, for the above statement is tantamount to saying: "I did not examine the accused."

Spirituous liquors, under the regulations, are not permitted on board ship except in the custody of the medical department for medical purposes.

Lighter alcoholic beverages formerly were permitted in the wine mess of the wardroom mess, but now are not allowed by regulation.

The smuggling of liquor on board is summarily punished. Men returning from liberty are sometimes found to have one or more "dogs" (bottles of whiskey) with them. Such men are punished. Women visiting ships not infrequently bring bottles of liquor under their skirts and sell them to the men.

When drinking is found among men aboard ships in port it is well quietly to keep a close watch upon small boats that hover around the ship, especially at night. Under cover of darkness such a boat may slip up silently to the ship's side, avoiding the regularly used ship's ladders, and attaching a bottle of whiskey to a cord lowered from an air-port, or overhang, they ply their nefarious trade.

Also the bumboats, small boats which come out to the ship and receive permission to sell fruit, candies, cakes, etc., to the crew, must be carefully watched. Bumboats are not now allowed (need for them is not felt since the establishment of the canteen), but an elastic construction of this prohibition often enables the purchase of fresh eggs and fruit.

Bottled drinks should not be purchased from such sources, for the

water of which they are made may be very bad. If these drinks are permitted to be sold a bottle selected at random and examined may be found to contain gin, despite its mendacious "soft drink" label. In the tropics men frequently like to purchase cocoanuts. There is no objection to this practice as they are highly nutritious, although indigestible. However, one should be on one's guard and inspect the cocoanuts carefully, for in some places they have been found to be filled with rum or alcoholics introduced through the "eyes of the nut" after draining away the milk.

Shellac is much used aboard ship. The shellac is "cut" or dissolved in alcohol. Although the alcohol is kept under careful watch, *i.e.*, lock and key, it not infrequently happens that after shellac is issued for use it is obtained by men who add water to it, thus precipitating the shellac, pour off the supernatant fluid, and add some sugar to this mixture of alcohol and water, thus making an alcoholic drink.

Wood alcohol is much used for cutting shellac. It is cheap and highly poisonous. Many ignorant people may fancy that it is grain alcohol and drink it with most disastrous results.

Several instances are recorded within my recollection of the fatal poisoning of men who have constituted wood alcohol cocktail parties. Such serious accidents have resulted from the drinking of wood alcohol that its use in the Navy has been prohibited.

It should be remembered in every case of sudden complete, or sudden partial blindness in persons below fifty years of age who have neither signs of inflammation or intraocular disease, nor history of concurrent trauma, that wood alcohol intoxication is perhaps most frequently thus manifested, and that the impairment of sight is apt to be permanent.

When serving with members of the hospital corps who are not tried men, it is well frequently to inspect the sherry, port, whiskey, brandy and alcohol. It is not enough to look at the wrapped bottle on the shelf. It may be empty. It may be filled with a colored substitute. It may be greatly diluted. Special care must be taken with reference to the key of the liquor locker and its custodian. Desire for liquor causes men to drink bay rum, alcohol off specimens, cologne water, etc. Compound tincture of cardamom is a favorite with the dipsomaniac as is paregoric. Users of Peruna, stomach bitters and other nostrums should be watched. Drinking coca cola should be discouraged.

Similar supervision of the poisonous and habit-producing drugs should be observed. A man of degraded type who suffers repeatedly with "cramps," nausea, etc., may well be made a subject of close observation to detect a possible opium addiction.

Cocaine is more widely used than is supposed. Its habitués are usually of most degraded type.

Surgeon Owens, of the U. S. Naval Medical Corps, recently has invited attention to a superficial ulceration of the nasal mucosa resulting from the snuffing of powdered cocaine. He believes this to be almost a pathognomonic objective sign in those whose condition and habits suggest cocaine addiction.

Cordite Eating.—Cordite, a high explosive, was much used by the British in the Boer War. The British soldiers were furnished with cartridges containing it. Some of the soldiers acquired the "cordite-eating" habit, eating the powder dry, or dissolved in beer or hot water. It causes a sense of exhilaration, and throbbing of the head with intoxication, and in about twenty minutes sleep comes on. From this sleep the habitué awakens with a severe thirst, most intense headache, and depression. This addiction has not been reported in our service that I am aware. Of course absinthe and other habit-producing drugs may be used, but the above are the ones chiefly to be expected.

Gasolene Jag.—Occasionally a man is found who intentionally inhales gasolene fumes for the purpose of getting their stimulating effect. Such individuals exhibit the signs and symptoms common to the stage of excitement in acute alcoholic poisoning. The odor of alcohol is absent, and not uncommonly that of gasolene may be detected. The symptoms may grow worse until convulsions supervene. Muscular incoördination appears to be less than in case of alcoholic poisoning, but the effect upon the nervous system is prompt and severe.

Tattooing.—Tattooing is a process of disfiguring the body by embedding in the derma particles of India ink or of colored pigment. It is difficult to understand the psychology of the individual who indulges in this form of self-abuse. It is common among the savages who appear to regard it as a form of adornment.

In the Marquesas Islands it has been a custom to tattoo one quadrant of a native's face. The portion of the island from which he comes is indicated on his face by the quadrant tattooed. The writer has seen a white man whose body was tattooed almost completely, producing a hideous effect.

The various designs which are tattooed into the skin appear to indicate in a measure the traits of character and mental trend of the individual permitting himself to be tattooed; for instance, an American in the Orient who possessed something of an artistic temperament had his body almost completely tattooed in the wistaria pattern. Religious emblems, war-like emblems, nautical designs, grotesque or comic figures, inscriptions, and obscene figures are seen.

Tattooing is prohibited in the Navy as it should be. It readily may lead to grave consequences. It often is done by a filthy needle, and the writer has seen more than one case of syphilis contracted in this manner, the initial lesion appearing at the site of the tattooing. Very frequently diffuse cellulitis of the forearm results from tattooing. It is evident that almost any infection may be inoculated on an infected needle.

Some of the professional tattooers have realized this and boil their needles, yet there are some who still do not boil their needles and who mix the pigments with saliva before tattooing it into the skin. The writer has seen one or two cases of large slough of the skin resulting from tattooing. Tattooing is believed to be less common than formerly among seafaring men.

CHAPTER XXVIII

GAS

Poisonous gases have been introduced into warfare by the Germans. It is not permissible to discuss offensive or defensive use of gases at this time further than to say that they are being used as:

(*a*) Drift gas;
(*b*) Gas shells.

(*a*) **Drift gas** is liberated to windward of an enemy and the cloud of gas drifts down the wind to him. An air current moving at the rate of about 5 miles per hour is most favorable for the use of drift gas. This method appears to be of little use afloat.

(*b*) **Gas shells** are charged with gas in compressed form or liquid, which liberates poison gas upon explosion of the shells.

These gas shells are made in all calibers. Accuracy of fire is necessary to their effective use. Obviously they should be so timed as to burst to windward of an enemy.

From standpoint of effect the gases used are:

1. Lethal;
2. Lacrimatory;
3. Sneezing.

1. The **lethal gases,** such as chlorine, bromine, phosgene, trichloromethyl-chloroformate, hydrocyanic acid gas, and the like, are intended to suffocate immediately, to produce fatal pulmonary œdema, or otherwise to kill at once.

2. The **lacrimatory gases** are those which produce active irritation of eyes and especially mucous membranes. It is evident that sufficient concentration of the lacrimatory gases would prove lethal. Xylyl bromide is used as a lacrimatory gas.

Dichlorethylsulphid, or "mustard gas" (so-called because it has the odor of mustard) is one of this type. It is a gas liberated from a liquid contained in some of the gas shells and when it comes into contact with moisture it produces burns.

These are superficial, but may result from the liquid falling upon the clothing. The caustic effect of the gas is very severe upon the conjunctiva and respiratory mucosa.

3. Sneezing.—Diphenyl-chlorarsin has been much used in effort to make men sneeze incessantly and thus interfere with their efficiency. It was intended also to force removal of protective gas masks and thus expose the victim to other poisonous gases.

Prophylaxis.—Avoid surprise attack. Gas masks of one of the several good types should be used. These should have non-splinterable laminated glass or celluloid goggles, preferably the former, as celluloid scratches easily and is inflammable. Gas masks are intended to neutralize the gas used in an attack, as well as to protect the head and face.

If a ship is overtaken by a gas cloud her ventilating system should be stopped, all openings closed and if possible she should speed up and get out of the cloud. Similar course must be pursued during attack by gas shells.

All on deck should wear gas masks.

CHAPTER XXIX

SEASICKNESS

Seasickness is a condition caused by the motion of vessels at sea and aggravated by disagreeable odors or other impressions upon the nervous system which might tend to produce nausea in the normal individual ashore.

Etiology.—Every man who goes to sea long enough and tells the truth has suffered or will suffer from this condition. Its obscure etiology has led to much speculation concerning the production of seasickness. It has been held to be due to disturbances in the semicircular canals, and in support of this thesis it is claimed that deaf mutes do not suffer seasickness. I have had no experience of this but have seen seasickness in persons who had lost hearing, including bone conduction in one ear.

Others claim that the condition is due to disturbances of retinal images and the effect upon accommodation as well, in looking out upon varying wave crests. It seems probable that accommodation is a factor. Many seasick persons experience great relief from closure of the eyes.

Still others hold that the condition is produced by the effect upon the splanchnic system as result of the unusual jolting of the stomach and other abdominal organs.

The theory has been advanced that seasickness is produced by impact of blood against the brain, due to the effect of the motion upon the blood in the circulating vessels.

The vasomotor system appears very closely associated with seasickness.

Prophylaxis.—The above are theories. Seasickness is a fact. Prevention of seasickness certainly is favored by proper function of the emunctories, recumbent posture, cool fresh air on deck near middle of the ship, the wearing of a belly-band, and avoidance of those sights, odors and conditions which normally would disgust or nauseate susceptible individuals.

Diversion is an important factor. I have seen Alexander Agassiz, when notified that a dredge haul was about to be landed on deck from the bottom of the sea, hurriedly and enthusiastically leave his bunk in quest of rare scientific specimens of marine life. Having carefully examined the results of the haul he would be overcome by *mal de mer*, from which he was a great sufferer, and with difficulty would make his way back to his bunk.

The case of a lieutenant who came up for promotion to grade of lieutenant commander is of interest in considering seasickness. Eight years previous to his examination for promotion he suffered an attack of typhoid fever. The official records and letters from the various medical officers with whom he served prior to the attack showed he had not suffered from seasickness more than is the experience of the average sea-faring man. After convalescence from typhoid he had a condition of "neurasthenia" which was manifested in good part by exceptional susceptibility to seasickness. When examined eight years after the attack of typhoid he showed certain psychasthenic symptoms, the chief of which was the obsession concerning seasickness. He stated that orders to a sea-going ship would make him sick and that he was unable to sleep at times because of contemplation of such orders.

His medical history was one containing numerous entries of incapacity for duty on large ships and small as result of seasickness. He is robust, 73 inches tall, weighs over 200 pounds, and a powerful looking man whose official record is one of excellent performance of duty and of commendation, except for the seasickness with which he is afflicted whenever he goes on board ship. He is a man of excellent habits, and repeatedly has tried to overcome this condition which appears to have developed since his attack of typhoid.

Careful examination of his ears, including the internal ear, shows no abnormality, in fact, except for slight tremor, complaint of nervous twitching, non-use of limbs at times, occasional pains and aches in various parts of the body, he appears to be a man of exceptionally good health and strength. It may be added that his habits with reference to use of alcohol and tobacco are excellent. After a struggle during the eight years which have elapsed since the attack of typhoid he appears to be a victim of chronic seasickness which apparently is of psychic origin.

In the aged and those who are weak and emaciated as result of disease, seasickness may prove a serious complication, and in cases of arterial sclerosis the vomiting may produce cerebral hemorrhages. In those with weak abdominal walls hernia may result from violent vomiting and retching. Usually, however, seasickness is harmless in its effects and the sufferer gets little sympathy from his fellow passengers. The favorite prescription given by "old salts" to those who are seasick for the first time is the drinking of a quart of sea water. It is eminently successful in causing prompt emesis, but this is the best that can be said for this treatment.

Each case of seasickness appears to be more or less a law unto itself, and hard and fast lines of prevention or treatment are difficult to establish. For instance, in my own case tendency to nausea is not so great on a full stomach as when the stomach is empty, and I have found that eating gives relief when nausea is marked. Closing the eyes gives relief to many persons.

Preparation preliminary to sailing will add comfort in the case of those who are predisposed. On the day preceding sailing, the bowel should be thoroughly cleared by castor oil, seidlitz powder or magnesium sulphate, and upon going on board ship susceptible individuals should immediately assume a recumbent posture on deck, if the weather permits, in a steamer chair which should be placed about the middle of the ship—a position in which the motion probably is least felt. Belladonna or atropine stimulates the circulation and tends to throw blood to the body surfaces, combating the mild degree of shock which accompanies nausea. One-thirtieth of a grain of strychnine thrice daily for two days before sailing tones the muscular system of those who are susceptible and is thought to be of value.

When vomiting is commenced the usual methods of treatment of nausea should be followed. The patient should be given small quantities of food at frequent intervals, and it must not be forgotten that the seasick individual is far better off on deck day and night than he is in the foul air between decks when the ship is battened down because of weather.

Diversion and will power play a large rôle in prevention of seasickness.

Bromides and other sedatives are prescribed at times for the relief of seasickness. It is not clear to the writer that depressants should be administered in cases of shock; and seasickness resembles shock in several respects not the least of which is *depression*. The exhibition of these drugs is apt to cause further discomfort to the stomach.

CHAPTER XXX

THE NERVOUS SYSTEM

Constitutional inferiority and the constitutional psychopathic state readily may pass the recruiting officer and remain unnoticed until some stressful condition brings a psychosis to the surface or discovers the constitutional inferiority.

Excitement, fear, anger, overwork, excesses, nostalgia, monotony, or injury may uncover the dormant condition.

The strain of long watches, submarine duty, physical discomfort, and the like tend to break even the rugged. The exactions of naval service bear heavily upon the mental weakling.

Exhaustion Psychosis

While training, and before they become hardened, men may present symptoms of exhaustion psychosis which resemble paresis.

J. Ramsay Hunt (Jour. A. M. A., January 5, 1918) has described a fatigue syndrome simulating early paresis. He has observed it among men who have been subjected to intensive training in army training camps.

These persons show tremor, iris symptoms, and slurring or speech disturbances upon repetition of test phrases—a symptom complex which has been regarded as almost diagnostic of paresis.

Syphilis could be excluded and after a few days of rest the nervous system regained its normal equilibrium with complete permanent disappearance of the symptoms.

Rest results in cure.

The British have found it best to send patients of this type to a rest cure immediately behind the battle line. The results justify continuance of this method.

Epilepsy

The epileptic also may pass the recruiting officer by concealing the truth concerning his infirmity. Frequently epileptics are seen in the

service and the character of their duties aboard ship necessitates their prompt discharge from service.

An epileptic helmsman might endanger the ship if siezed by a convulsion while at the wheel.

An epileptic's infirmity might result in his own drowning if he should fall overboard during an attack.

The physical courage of the epileptic is proverbial. Napoleon Bonaparte was an epileptic. A noted alienist stated he would rather lead a command of epileptics into battle than an equal number of normal men.

"The epileptic does not know fear."

Shell Shock

The concussion following the passage or explosion of a shell near an individual may cause even death, with or without visible injury.

If death does not occur one may see almost every conceivable mental, motor, or sensory disturbance.

Some present the text-book picture of neurasthenia, while others run the gamut of hysterical manifestations, or suggest organic disease.

Wilshire remarks the infrequency of shell shock among those who have received wounds. This seeming immunity of the wounded is thought to be due to the neutralization of the action of the psychic cause of shell shock by the wound.

Psychic exhaustion as result of horrible sights, fear, or continued anxiety predisposes to shell shock.

Carbon monoxide poisoning following explosion of the shell has been thought to be a possible cause, but it is improbable that the gases alone are responsible for shell shock. A constitutional inferiority or psychopathic state is the basis upon which shell shock develops. "Shell shock" or war-strain may not necessarily be caused by shell fire.

Neurasthenia, hysteria, and malingering must be considered in making a diagnosis. Salmon states: "Neuroses constitute one of the most formidable problems of modern war."

Wounds

As result of trauma, however produced, injury to the brain or nervous system may result in impairment of function varying as much in type and degree as the trauma may vary in character and intensity.

Paralyses resulting from nerve injury are being treated by reëducation after surgery has done its utmost to restore function.

Most gratifying results are being obtained from this "rehabilitation," and members formerly considered useless now are made functionally useful.

Prophylaxis

Prevention of the various non-traumatic mental and nervous conditions occurring in the naval service requires recognition of the fact that all of them depend upon an original neuropathic or psychopathic basis.

The individual has not normal mental or nervous capital from the outset. He is nervous, brooding, apprehensive, depressed, easily frightened, or shows other evidence of neurotic type. Whether the condition which develops be that of a functional disorder or of organic disease the history usually will show a constitutional inferiority or psychopathic state.

Obviously:

(*a*) Such persons should be rejected at the recruiting stations;

(*b*) Should be eliminated from service at the training stations; or

(*c*) Should be placed in positions where stress may not develop symptoms.

They are not "first-line men." Their example may demoralize others. Their memories are unreliable. They are untrustworthy. Medical officers should watch carefully members of the crew who show any unusual emotional tendency or other evidence of psychic abnormality. Such should be weeded out at earliest opportunity. They are reeds which tend to break when support is most needed.

"The trenches is no place for a man with unstable vasomotors" (Osler).

CHAPTER XXXI

NUTRITIONAL DISEASES

Scurvy.—Scurvy formerly caused much incapacity among the sea-faring population who were compelled to subsist upon salt meats and hard tack during the long time often consumed in making passage.

Upon the discovery that scurvy is a nutritional disorder and due to deficiency in the diet of certain constitutents (organic acids) necessary to normal metabolism, a quantity of lime juice was added to the daily ration and was found to be a valuable prophylactic. The sea-faring population of today seldom suffers from this disease.

Fresh meats, vegetables, and fruits supply the necessary nutrients and vitamines to prevent development of the disease and only occasionally in the merchant service is scurvy to be seen. The ration of the Navy has such a liberal proportion of anti-scorbutic constituents that we may say the disease is never seen in the Navy.

Beri-beri.—Beri-beri is essentially a polyneuritis resulting from nutritional disorder. It has been more or less prevalent among those who are accustomed to a ration composed principally of polished rice. Oriental sailors who subsist largely upon rice frequently are attacked by this disease.

Eijkman demonstrated in 1890 that a diet of polished rice would produce polyneuritis in fowls, and Funk isolated from rice polishings in 1911 a crystalline organic base which will cure or prevent polyneuritis in fowls.

The crystalline organic base was called a "vitamine." This base has been found in other foods, *e.g.*, fruits, vegetables, milk, eggs, and fresh meat. Absence from the diet of the necessary quantity of "vitamines" results in beri-beri. These may best be obtained in a varied diet. Monotonous starchy diet will produce beri-beri, hence at sea a liberal, varied dietary should be provided.

Heiser and others have shown that beri-beri is produced by eating polished rice, and that it may be cured by feeding rice polishings provided the cases have not advanced too far. So conclusively has

this been shown that the Philippine Government has required the general use of unpolished rice.

Despite the fact that beri-beri can be produced by a prolonged diet of polished rice and that the disease can be cured by the feeding of the polishings, there are some who hold the theory that the disease is due to a germ which lives in rice.

Labredo thinks he has isolated an organism which he states is found in rice and regards as the cause of beri-beri. His observations lack confirmation, and in view of the overwhelming evidence that the disease is a nutritional disorder directly preventable by the feeding of a balanced dietary, the theory of germ origin of the disease scarcely seems tenable.

In countries where rice is the principal article of food it should not be polished, and as further measure of disease prevention, fresh food and legumes should be eaten.

Years ago beri-beri was a scourge in the Japanese Navy and the addition of appropriate nutrients to the ration then in use gave a brilliant demonstration on a large scale of the favorable results which attend proper feeding in cases which have not progressed too far. This disease is prevented by a balanced ration. It has not been seen in the United States Navy. Medical officers, however, may encounter it among oriental colonials serving in crews of navy auxiliaries.

At the siege of Kut-el-Amara beri-beri appeared among the British troops who were on a ration of white wheaten flour, and disappeared when the British were put upon the coarsely milled grain ration of the Indian troops coöperating with them.

British observers conclude that the germ and bran should be included in the flour intended for food.

CHAPTER XXXII

HEAT CRAMPS

Under certain conditions not too well understood the men in fire rooms develop severe cramps. High temperature and excessive humidity appear to be predisposing causes. Whether the condition is the result of retention of catabolic products in excess of the body's ability to eliminate them or whether it is due to deficient supply of carbohydrate in the system is not known. Possibly both causes acting together produce the effect.

I have never observed a case of cramps in the engine-room force. The engine rooms usually are hotter and more humid than the fire rooms. The work of those in the engine room is far less arduous than that of the coal passers and firemen who are working below in a dryer heat, but performing extremely laborious work, consequently are oxidizing more tissue, and frequently suffer from cramps.

Deficiency of circulating fluid in the system has been suggested, but I have found the pulse full and bounding in patients just seized with cramps, and again have found cases in which there appeared to be circulatory depression. The patients have not appeared "dried out."

Some individuals appear predisposed to heat cramps and develop them on slight exposure. I have seen an instance in which repeated attacks occurred in a young man who tried to perform the duties of his rating even after he was advised not to do so because of recurrence of cramps at intervals of possibly months.

In a typical case of heat cramps the victim may have slight premonitory cramping of the calf of the leg, or possibly of abdominal muscles, which may be considered intestinal by him.

After being on watch for some time an acute attack comes on and may be limited to one group of muscles or to an extremity provided the man stops work at once, but if he continues to work general cramping of the muscles of the extremities, back, abdomen and neck will become most distressing.

These cramps are more or less tonic in character and muscles may be drawn into hard tense masses. In occasional instances the patients are unconscious. This is rare. The individual seized with cramps in the fire room usually is carried to the sick bay, writhing in excruciating pain.

My experience indicates that the **temperature is subnormal although it appears normal.** One who has stood the major portion of a watch passing coal, or before the fires, usually will be found to have a physiological temperature varying up to 102.5°F. as result of his arduous labor and exposure to heat. When seized with heat cramps or heat prostration, even though the mouth temperature is shown to be 98.4°F., this temperature, normal for individuals at rest, is subnormal for those who have been exposed to the conditions above mentioned. The pulse usually is weak and rapid, running from 120 to 140. One case observed by me showed a very weak pulse of 72. Respiration is about normal, except as modified by the convulsive efforts caused by the cramping. Patients usually are conscious and perspiring. Constipation has not appeared to be a factor.

The **urine** commonly is scanty and high-colored. Its specific gravity has been found by me as high as 1034 and reaction acid. **In every case albumin is present.** Sugar is absent.

Microscopic examination of the sediment shows evidence of **acute irritation of the kidneys.**

The Blood.—As result of loss of body fluids the hæmoglobin as measured by the Talquist scale appears to be about 100 per cent., red cells from five to six million, white cells about normal.

Nothing remarkable was shown by the differential count.

In some cases vomiting appears and this has seemed explosive in character, suggesting cerebral irritation.

Heat cramps are said to be more common on destroyers under forced draft than in battleships. Under these conditions the air pressure equals 5 inches water gauge; in the battleships, 2 inches.

The following notes illustrate what may be met at any moment among the fire-room force of a dreadnaught battleship:

Case 1.—At sea. Dry bulb 69°; wet bulb 68° (on deck). Barometer 30.29. Fireman, 2 cl., age twenty, born U. S.; father English and mother German; previous occupation, teamster; had measles in childhood; has been two years in Navy; has been fireman, ten months; has had two previous attacks of heat cramps—once en route from Guantanamo to Colon, the other on Southern Drill Grounds—both

under forced draft; ate full noon meal before going on watch; urinated last before attack at 12 : 10 p.m.; bowels moved last before attack eighteen hours previously; drank five cups (about 1500 c.c.) of water during the 12–4 watch; sweated freely during watch; was under natural draft (ventilator) during first two hours and forced draft last two hours of watch; has had good health immediately preceding the attack.

Attack.—Carried into sick bay suffering with violent cramps especially in muscles (extensor groups) of extremities and abdomen. Contractions appeared almost wholly confined to extensors—clonic spasms lasted two to three minutes.

Temperature (by mouth) 98.2°F.; pulse 135, weak; skin cool and drenched with sweat; respiration normal. No headache, nausea, vertigo, vomiting or involuntary action of sphincters. Pupils react normally. Reflexes normal. Patient conscious. Slight cyanosis of skin. Possibly heart was enlarged slightly. Urine: about 200 c.c. of **highly albuminous urine** (T. 98.2°F.) passed about four hours after attack. Analysis not completed because of darkness in darkened ship in battle practice.

Patient was placed in warm bath and given 10 minims of Tr. belladonnæ. Massaged. Free ingestion of fluids urged. Within forty-eight hours patient returned to duty.

Case 2.—At sea. Dry bulb 72°; wet bulb 71°; barometer 30.04 (on deck). Fireman, 1 cl.; age twenty-five; nat. U. S.; both parents Irish; "never in bed a day in my life;" served nearly three years as coal passer and fireman; bowels moved freely 7 : 30 a.m.; urinated last about forty-five minutes before attack; had 8–12 : 00 p.m. watch on August 22 and felt O. K. when went on watch at 8 : 30 a.m., August 23. Drank no water on watch before attack. ("It gives cramps more than anything else to drink cold water when on the fires," he says.) Blowers at full speed series, forced draft.

Attack.—Violent cramping in abdominal muscles, shoulders, back of neck, and extremities, especially in extensors of back and calves of legs.

Temperature 98.4; pulse weak and 72; respiration normal; heart normal; reflexes normal; perspiring freely. Heart area not enlarged. Seized about 10 : 00 a.m. Temperature in fire room 119° dry bulb.

At 12 : 45 p.m. he passed 200 c.c. of highly albuminous urine, and only 500 c.c. during first twenty-four hours after watch. Urine neutral, sp. grav. 1034; no sugar, **much albumin;** many hyaline casts; few blood cells; and epithelium.

Case 3.—At sea. Wet bulb 72°; dry bulb 72°; barometer 30.03. Coal passer, age twenty-two; nat. U. S.; parents U. S.; has been in Navy one year as coal passer, except three months as fireman. Had 8–12 midnight watch. Ate full breakfast and went on watch at 8 : 00 a.m. Last defecated 8 : 00 p.m. evening before attack. Last urinated three hours before attack.

Has had measles, chicken-pox, and mumps. Was passing coal when seized. Was able to walk to sick bay. Was dizzy, pale, faint, perspiring, pulse 140 and weak. Temperature normal. Respiration normal. Severe cramping in flexors left thigh, and extensors of both legs.

Passed no urine until 6:00 p.m.

Urine—neutral reaction; sp. grav. 1026; no sugar; **albumin in abundance,** ppt. = 16⅔ per cent. vol. of tube; no blood, epithelium present. Total quantity for twenty-four hours 450 c.c.

Case 4.—At sea. Dry bulb 76°; wet bulb 75°; barometer 30.23 at 4:00 p.m. Had 12–4:00 p.m. watch. Had cool to tepid bath coming off watch. Cramps came on in flexors of extremities and later in abdomen and cervical muscles. Came for treatment two hours after coming off watch. Reflexes normal, but the eliciting of the patellar reflex causes a violent cramping in adductors of thigh of leg under examination. Possibly this was coincidental, but it is believed that the striking of the patellar tendon caused the cramping, as it appeared after each blow.

Temperature 99.4; pulse weak and soft, 120; respiration 18. Great prostration and weakness. Free perspiration. No urine passed from 6 : 00 p.m. to 9 : 00 a.m. when 125 c.c. were voided.

Urine—somewhat smoky; sp. grav. 1029; reaction, faintly acid; **albumin, very heavy trace**; sugar, none. Numerous hyaline casts, some with epithelium attached, urates, few calcium oxalate crystals and blood cells (few red cells) and some renal epithelium.

Case 5.—At sea. Wet bulb 69°; dry bulb 68°; barometer 30.03. Fireman, 2 cl.; age twenty-two; nat. Iowa; both parents German; patient has had gonorrhea and tonsilitis.

Went on watch 8 : 00 a.m. and came off at 12 : 00 m. Ate full breakfast and dinner. Last evacuation twenty-four hours before attack. Last urination one hour before going on watch 8 : 00 a.m. Did not urinate during watch. Sweated profusely. Drank abundance of moderately cold water. Cramps came on while washing up after watch (not severe) but three hours later became so bad as to cause patient to apply for treatment. Temperature 98.4°; respiration 24; pulse 82 (three hours after watch).

Patient worked under forced draft, blowers at full speed.

Passed small amount of urine.

Urine—reaction, acid; sp. grav. 1020; **albumin, large amount**; sugar, negative. Hyaline casts and epithelium.

An engineer officer who served on the U. S. S. Minnesota states that the members of the fire-room force appear far less susceptible to heat cramps after eating canned tomatoes or canned fruit, especially canned peaches. My own observations indicate that increase of carbohydrate in the shape of sugar saves tissue oxidation, and tends to prevent heat cramps.

The following is quoted from a report made by me concerning an endurance run of a first-class battleship during November, 1915. The men were examined physically before the trial was commenced and after the trial was completed. It should be borne in mind that during an endurance run the maximum possible speed is got out of the engines during the run. This full power run always taxes the personnel of the engine and fire rooms, and those having tendency to heat cramps are apt to develop them:

Report of Full Power Run

(*a*) Physical condition of personnel before trial was excellent.

(*b*) During trial physical condition appeared excellent.

(*c*) No cramps or after-effects of consequence were observed.

(*d*) All men observed appeared to be physically qualified for the arduous duty being performed.

(*e*) Water from scuttle-butt at temperature of about 55°F. was the only fluid known to have been used for drinking. Bucket for fresh water bath and salt shower constituted type of bath used.

Ventilation appeared to be adequate under conditions in which full power run was made. Thermometer on deck registered dry bulb 50°F., wet bulb 50°F., averaging this during the watch.

The following thermometric observations were taken during the full power run (about 11 : 30 p.m.) the run being from 8 : 23 p.m. to 12 : 23 a.m.:

	Dry bulb	Wet bulb
Steering engine compartment	106°	77.5°
Engine-room platform	101°	76.0°
Fire room No. 1	98°	68.5°
Fire room No. 2	92°	68.0°
Fire room No. 3	88°	64.5°

Above temperatures indicate very favorable working conditions, especially as to humidity. No special contamination of air was noted except the coal dust in fire rooms and oil odor in engine-room spaces.

Special observations were made upon the men, fire rooms 1 and 2.

Sugar ("domino") was given ad libitum to the eighteen (18) men in fire room No. 1, while no sugar was given to the same number of men under same conditions in fire room No. 2.

Following comparisons are made for what they are worth. Inability properly to conduct the experiment without interference with the paramount issue, viz., keeping up steam, causes the data here given to be less valuable than it might have been. Data relative to weight are closely approximate while those relative to pulse and temperature are accurate (temperature by mouth).

Weight average, not stripped, but in clothes:

	Before run	After run
Fire room No. 1	154.9	153.0
Fire room No. 2	160.3	155.0
Temperature average:		
Fire room No. 1	98.4	98.3
Fire room No. 2	98.0	97.4
Pulse average:		
Fire room No. 1	81.5	98.5
Fire room No. 2	80.9	102.7

Urine in 23 specimens showed:

Negative albumin	14
Slight trace	7
Trace	1
Heavy trace	1
	23

Comparison of urinalyses shows negligible difference between the men using sugar and those who were not given sugar.

Subject to foregoing remarks concerning accuracy of data it is noted that the following average loss in weight occurred:

Fire room No. 1	1.9 pounds.
Fire room No. 2	5.3 pounds.

Temperature observations indicated no marked variations. It is believed that observations of rectal temperature would have shown different results.

Pulse:

	Before run	After run
Fire room No. 1	81.5	98.5
Fire room No. 2	80.9	102.7

The men of fire room No. 1 showed an increase of 17 beats per minute, while those of fire room No. 2 showed an increase of 21.8 beats, a difference of 4.8 beats. In other words the hearts of the 18 men to whom sugar was given performed 20.8 per cent. additional work during the watch; while the hearts of the 18 men who received no sugar (other than ration served to both groups) performed 26.9 per cent. additional work during the watch—or 6.1 per cent. more than the sugar-fed group. But when the percentage of additional work is considered:

Group No. 1	17.0 beats per minute
Group No. 2	21.8 beats per minute
Difference	4.8 beats per minute.

represents about 28 per cent. of the additional work performed by the sugar-fed group. The hearts of group No. 1 did 28 per cent. less additional work than group No. 2. With full appreciation of the unavoidable crudeness of the experiment and of the inaccuracy of some of the data above given it would appear that the sugar-fed group suffered less exhaustion during their arduous work. Was sugar responsible wholly, or in part for lessening the work of the hearts of group No. 1? It is believed it played a considerable part, and that further better controlled observations may be worth while.

Prophylaxis.—Men having kidney lesions should not be permitted to pass coal or to fire. Unseasoned men should not be put on fires in hot weather if it can be avoided. Heat prostration is more apt to occur when the reading of the dry and wet bulb thermometers are

about the same. I have seen cases occur when the wet bulb thermometer on deck read 68°, 69°, 71°, 72° and 75° respectively. The fire-room temperatures were not excessive at these times. The experienced fireman knows that the drinking of cold water tends to precipitate heat cramps, and it is not uncommon for the cramping to occur after a man has been away from the fires several hours. Men of experience in the fire room will not drink cold water. Many prefer barley water which they make lukewarm. Some experienced firemen attribute cramps to sudden chilling, *e.g.*, standing under forced-draft blowers. This should be avoided. Increase of carbohydrate as **sugar or glucose in diet should be tried by those subject to heat cramps.**

Treatment.—Immerse patient in hot bath at once, administer atropine or belladonna, give cool, *not cold*, fluids by mouth. If necessary morphia may be given for relief of pain. In extreme cases intravenous injection of 0.6 per cent. salt solution (*i.e.*, below normal strength) may be necessary, as may the administration of glucose solution.

CHAPTER XXXIII

SPUTUM-BORNE DISEASES

The communicable diseases which are transmitted through the sputum have received too little attention from the profession at large. A moment's reflection brings the realization that tuberculosis, syphilis, and many other diseases of lesser importance are transmitted by this medium, and that the proper control of oral and nasal secretions will greatly reduce the morbidity and mortality from these diseases. The secret of prophylaxis lies in the complete disinfection of the sputum. This disinfection or destruction should be done uncompromisingly, for the single expectoration of a tuberculous or pneumonia patient is a potential source of infection for a number of susceptible individuals.

The disinfection of the sputum may be accomplished by:

(*a*) Physical means;
(*b*) Chemical means.

(*a*) **The physical means** may be:

1. Burning;
2. Boiling;
3. Burying.

(*a*) **Physical Means.**—1. *Burning.*—When the sputa are received in paper sputum cups, or in paper handkerchiefs, or in the sawdust which is occasionally provided for the purpose, destruction by fire is by far the best method of disposing of the infectious material.

Nurses or others engaged in handling the sputa should be especially cautioned of the danger and should disinfect their hands after each handling of sputum.

2. *Boiling.*—Incombustible sputum cups or containers or other incombustible articles which will not be injured by boiling may be boiled for twenty to thirty minutes and their sterilization effected. This method of disinfection should be employed in the sterilization of linen soiled by sputa.

3. *Burial.*—It is conceivable that occasion may arise when neither of the foregoing methods is practicable and burial must be resorted

to. This method of disposition is extremely undesirable and unsatisfactory if necessary at times.

If in the field it becomes necessary to dispose of sputum by burial, the depth of the pit used should not be sufficiently great to reach the ground water level, as this might result in infection of nearby wells or springs. The discharges should be covered with chlorinated lime before the pit is filled with earth.

(*b*) **Chemical Means.**—The chemical disinfection of sputum may be accomplished by the addition of crude carbolic acid, 2 per cent. Bichloride of mercury solution should not be used because it forms an albuminate of mercury which envelopes the viscid sputum mass, but fails to penetrate to its interior, consequently it fails to kill the organisms which are incorporated in the sputum.

In addition to the destruction of sputum a campaign of popular education concerning the dangers of sputum-borne diseases should be begun early in life. The writer is of opinion that instruction concerning sputum-borne and other communicable diseases should be a part of the curriculum of the grammar schools of the country. It is better that the youth of the country be rugged and strong even at the expense of what we are today pleased to call "education."

The dangers attendant upon coughing and sneezing should be taught and the covering of the nose and mouth with the handkerchief should be thoroughly impressed, together with the fact that persons apparently healthy may by coughing or sneezing transmit a fatal pneumonia, cerebro-spinal meningitis, tuberculosis or other communicable disease to susceptible individuals.

The **use of paper handkerchiefs** should be encouraged, and their manufacture should be so cheapened, as in Japan, that they will replace the less sanitary cotton, linen and silk handkerchiefs which are not sterilized nearly so frequently as they should be. The paper handkerchiefs should be burned after use.

The anti-spitting laws should be carefully enforced, as should be the safe and sanitary method of covering the nose and mouth in sneezing and coughing.

Persons affected with sputum-borne diseases should be made to realize that they are a danger to the community and they should be impressed with the obligation incumbent upon them to do their share in preventing the spread of their diseases.

Sputum should be received in covered cups to prevent access of

flies, roaches, or other insects which may travel from the sputum cup to prepared food, carrying disease as they go.

Likewise domestic animals, such as cats and dogs, may nose around an uncovered sputum cup getting their muzzles soiled and so conveying infection to persons petting the animals.

The sputum-borne diseases may be classified into those due to:

1. Bacilli;
2. Cocci;
3. Spirochæte;
4. Flukes;
5. Those of unknown cause.

1. The *bacillary* sputum-borne diseases are pneumonia, tuberculosis, typhoid fever, cholera, plague, bacillary dysentery, diphtheria, Vincent's angina, whooping cough.

2. *Cocci.*—Streptococci—several forms of tonsilitis; diplococci—cerebro-spinal meningitis.

3. *Spirochæte.*—Syphilis, Vincent's angina, and *Spirochæte icterohemorrhagica* (?).

4. Those due to *flukes*—lung fluke or *Paragonimus westermanii* and *Fasciola gigantea* (both rare).

5. Those due to *unknown causes*—measles, chicken-pox, German measles, scarlet fever, yellow fever, mumps.

Sputum should be recognized as a more common source of disease than urine, and its disposal should receive more consideration than is accorded to the less dangerous urine.

Improper disposal of sputum aids in the spread of diseases and pus infections. The working of the present method of sputum disposal is far from possible attainment.

The galvanized iron cuspidors now in use have a diameter of 10 inches at the top, 9 inches at the bottom, and an inside depth of 5½ inches. These cuspidors partly filled with water are placed at convenient points in the living spaces. They are easily moved about, their contents being slopped over as they are stumbled against by a careless skylarker or sweeper. Too frequently the cuspidor is *spat at rather than into.*

At a recent captain's inspection thirteen out of fourteen spit kids showed evidence of fresh or dried sputum upon the outside or upon the deck in the immediate vicinage. It must be admitted that in some cases the sputum lay not as it fell on

deck, but was smeared out into a comet shape by a watchful swab. The exception (counted for loyalty to fact) was placed behind some mess tables where conveniently it could not be spat at.

As cuspidors of the type now furnished are mobile they merely multiply foci of deck infection, the particles of inspissated sputum floating in the dust-laden air of compartments which are the sites of such varied activities, and the domiciles of so many who may be susceptible to infection. Since expectoration aboard ship is recognized by supplying cuspidors, it seems desirable properly to provide for

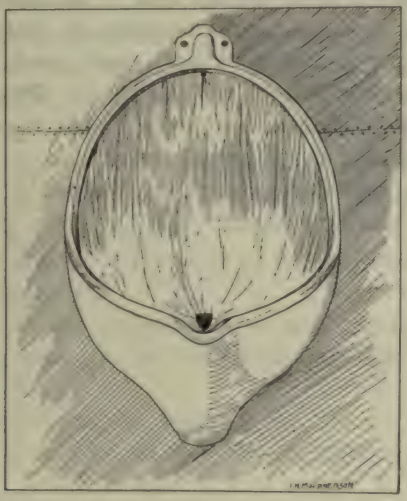


FIG. 130.—A cuspidor-urinal suggested by the writer. It should have a somewhat larger bowl than the urinal in common use and should be flushed constantly by salt-water in such manner that its entire inner surface is bathed with the moving salt water. This cuspidor-urinal should be fixed on the bulkhead and would be nearer to the source of the sputum.

disposal of sputum. For sanitary reasons and because of offense to our æsthetic sense, we provide at convenient places on board ship, self-flushing urinals for disposal of urine in a prompt and sanitary manner. No such provision is made for removal of sputum despite the fact that more disease is spread by sputum than urine.

Viscid, dangerous sputum is expectorated at long range toward a small mobile cuspidor while the less dangerous urine is voided into a flushed urinal, offering a larger target, at shorter range, and with better facilities for aiming.

Perhaps it is Utopian to hope for **flushing cuspidors** properly located aboard ship at this time, but it is believed that it is feasible and desirable to place upon brackets on the bulkheads removable cuspidors 15 inches in diameter and 8 inches deep, the mouths of the cuspidors to be 40 inches above the deck. The cuspidors should be provided with steel straps which could be made a part of the suspending apparatus and serve as a handle when cleaning is done, thus avoiding the danger incident upon handling the cuspidors. Such a cuspidor would possess the advantage of being 40 inches nearer the source of sputum, would have a larger mouth, and its location on the bulkhead would necessitate approaching the cuspidor in order to use it. The location on a white vertical bulkhead would render improbable the careless use or kicking over of the receptacle. **Properly constructed** and located **cuspidor-urinals** about 40 inches high are desiderata, and **should be provided as are urinals today.**

The cuspidors now in use aboard ship should be boiled or steamed daily during the morning watch.

CHAPTER XXXIV

INFECTIOUS DISEASES

When armies are in the field at work their morbidity rate is lowest. It increases with the idleness which results from prolonged stay in garrison and camp.

So with the naval personnel. Their morbidity rate increases when they arrive in port, and are exposed to the various disease-producing influences not usually found aboard ship, *e.g.*, foci of infection, drink, and prostitution.

Idleness and sickness go hand in hand.

To fight intelligently an infectious disease requires:

1. A knowledge of the cause.
2. An understanding of its mode of transmission.
3. Isolation of the sick.
4. Prevention of the scattering of contacts and suspects.
5. Proceeding against the causative organism and against its intermediate hosts.
6. Disinfection of excreta, clothing, etc.
7. Disinfection of the patient. He is more dangerous than the room.
8. Treatment or isolation of carriers.

Venereal Diseases

Venereal diseases probably are responsible for more suffering, economic loss, and impairment of efficiency in the naval service than any other class of diseases affecting its personnel. Figures are not yet available for the expression of damage done during this war. But in recent years, in time of peace, enough men have been on the sick list constantly to make the damage to the naval service equivalent to placing one dreadnaught battleship out of commission for every day during the entire year.

The Surgeon General's office shows the following average of the

annual admission rates per 1000 for the decade ending January 1, 1917, viz., chancroid, 29; gonorrhea, 82.81; syphilis, 22.14

Venereal diseases, *i.e.*, gonorrhea, syphilis, and chancroid, have cost inestimable suffering to the personnel of the Navy, and any effort to improve conditions should meet with hearty coöperation on the part of the administrative authorities.

So long as men are men, and women are women, the natural instinct for preservation of kind, an instinct second in power only to self-preservation, will find its manifestation. Society in our country has been prone to condemn frank discussion of this subject and the topic has been hedged about with a secrecy which has done much to further the cause of evil and prevent the competent, intelligent control over a condition which has forced recognition. Until society has attained a moral plane far above that upon which it now stands, illicit sexual congress will continue, and venereal diseases will be disseminated.

It seems wise to recognize the existence of conditions, to take a masterful grip of a bad situation and control it. Not a little moral guilt is attached to those who, closing their eyes, imagine that by so doing they are preventing existence of the social evil and its trail of disease and suffering.

Mothers and fathers are remiss in a sacred duty when they fail to instruct concerning the care and function of the reproductive organs and the inevitable dangers which lurk in the pathway of the young men and young women who go into the world without a proper knowledge of the dangers of violating natural laws in respect of exercise of the generative function.

The above-mentioned prevalence of venereal diseases in the naval service is not to be construed as an implication that the personnel of the naval service is worse with the respect of sexual morality than a corresponding number of men of the same ages and walks in life. The most accurate statistics concerning the movement of venereal diseases among males are the statistics compiled for years past by the Army and Navy. The men in the naval and military service undergo a careful physical examination upon enlistment; are under constant medical supervision, and, with the exception of a few cases which are concealed, accurate records are kept because of the bearing of venereal diseases and incapacity resulting therefrom upon probable future pension claims. Nowhere else in the country are kept such accurate statistics concerning these diseases. Recently some states have made

venereal disease notifiable, but even here the self-treatment, and the treatment suggested by the cupidity and ignorance of a drug clerk, do much toward vitiating statistics which, from other points of view, are not too dependable. The young men of the Navy are drawn from civil life and return to civil life when they leave the Navy. They cannot catch gonorrhea from a thirteen-inch gun or syphilis from the performance of routine duties. In order to acquire venereal diseases they must return to the civil life whence they have come and where vicious women give disease in exchange for money.

Enlisted men of the Navy suffering with venereal diseases in an infectious stage are not granted shore leave. It is regretted that civil communities do not similarly quarantine their venereal cases.

Just here it may be noted that prostitutes are probably the most insidious and dangerous of spies. They ply their nefarious trade for the purpose of obtaining information from their partners in crime and communicate it to the enemy who has sent them out. Infected women may be employed by the enemy to infect opposing forces. One infected woman may spread disease to so many as 25 men in a single night. While in Alaska the writer was told of a prostitute who limited her favors to periods of twenty minutes and actually sold tickets for a definite time and guaranteed their turn to purchasers.

The prevention of venereal diseases in the Navy is a difficult problem and may best be met by: first, education; second, occupation; third, diversion; fourth, abstinence from alcohol; fifth, prophylaxis.

1. **Education.**—The education of the individual should begin early in life. Usually instruction has not been given until after men are in the Navy and have learned much that is false concerning sex hygiene. The medical officers should instruct officers and men, in groups of convenient size, concerning the prevalence, mode of infection, prevention, complications and dangers caused by these diseases. Such instructions should be thorough and should be repeated sufficiently often and simply to insure that there is a general understanding concerning the various phases of the diseases mentioned. It is not considered that the clinical aspects of the diseases or the treatment should be given, but rather that the great damage inflicted and methods of avoidance of the diseases should be taught.

The very common belief that virility will be lost unless there is indulgence in sexual intercourse should be strongly combated, and men should be taught that they will be stronger, healthier men and better

fitted for paternity if they are continent until such time as they desire to leave children to inherit their names. Seminal emissions usually indicate *sexual strength.* Men should be taught this in lecture and in leaflet.

2. Occupation.—Idleness is a breeder of vice and vicious habits. Work should be so arranged as to keep men employed and to produce physical fatigue which will tend to lessen sexual desire. Occupation will crowd out thoughts and suggestions of libidinous character.

3. Diversion.—For the same reason that occupation is desirable, diversion and amusement should be provided for men during their resting hours. Reading, games, athletic contests, amateur theatricals, moving pictures, all are useful.

4. Abstinence from Alcoholic Drink.—Alcohol is responsible for a large amount of venereal disease. It tends to inflame the passions and lessen the will power, and individuals who have no intention of indulging in sexual intercourse after a debauch will find that they have exposed themselves to at least the possibility of infection.

5. Prophylaxis.—Prophylaxis may be considered under two headings: (*a*) general, (*b*) personal.

(*a*) *General.*—Brothels and saloons should be cleared out from the vicinage of training stations and camps. Prostitution should be made difficult. Diseased women should be quarantined and treated until they are no longer capable of transmitting their infections. This method has proved satisfactory in Italy where dispensaries for the examination and treatment of infected individuals have been provided. Venereal diseases should be notifiable just as other infectious diseases.

(*b*) *Personal.*—Disciplinary action should be taken against officers and men who develop venereal diseases if after exposure they have not availed themselves of personal prophylaxis.

Medical officers and divisional officers while discouraging prostitution should inform the men under them that personal prophylactic measures must be taken immediately upon return to the ship after sexual intercourse. This information should be thoroughly disseminated throughout the ship and the venereal prophylaxis room should be open at the hours during which liberty parties are returning.

A hospital corps man, carefully trained in the method of prophylactic treatment, should be in attendance. The medical officer should not be present as his presence is apt to deter individuals from coming. The hospital corps man should keep a careful record showing the name

and rate of the person treated and hour and date of all treatments given. This record will be of value for reference when cases of venereal disease report at the sick bay for treatment. If the record shows that the individual has contracted venereal disease after having taken prophylactic treatment, he should not be made the subject of disciplinary action. If the record shows that he has not availed himself of the preventive measures provided he should be reported for punishment.

The prophylactic treatment consists in thoroughly scrubbing the parts with soap and water and after urination injecting into the urethra a 1 per cent. protargol or 10 per cent. argyrol solution. The injection should be made only into the anterior urethra, being prevented from going backward by pressure with the finger upon the canal. This injection should be repeated three times, each injection being allowed to flow out, the final one being held for a period of five minutes.

After the injection the organ should be anointed with 33 per cent. calomel ointment in lanolin. This should be thoroughly rubbed in, especial attention being paid to the region of the frenum. The ointment should not be washed off.

While perhaps falling short of the extravagant claims of enthusiasts, carefully carried out personal prophylaxis undoubtedly reduces the incidence of venereal diseases by its antiseptic effect and by its educational results.

Medical Director C. E. Riggs, U. S. N., reported the following results from 3556 prophylactic treatments at the Naval Training Station, Norfolk, Va.:

Administered within		Venereal disease developed
First hour	674	0
Second hour	657	4
Third hour	298	2
Fourth hour	223	1
Fifth hour	156	3
Sixth hour	285	4
Seventh hour	247	5
Eighth hour	359	16
Ninth hour	272	9
Tenth hour	190	10
Eleventh hour or over	195	13
Total	3,556	67

These figures emphasize the necessity for immediate prophylactic treatment after exposure.

The percentage of men who developed the disease despite prophylactic treatment taken within three hours after exposure was 0.37 while the percentage among those who allowed nine hours to expire before prophylactic treatment was 5.97.

The distribution of prophylactic remedies to men as they go on liberty has not met with general approval, because;

(*a*) It suggests sexual congress to them;

(*b*) It probably causes more exposures;

(*c*) Too frequently men who indulge in illicit sexual intercourse are too drunk to apply the prophylactic properly.

Diphtheria

Diphtheria is an acute communicable disease due to *Bacillus diphtheriæ*, and characterized by the formation of a membrane at the site of infection, great prostration, and albuminuria.

In training stations and aboard ship it appears from time to time in epidemic form, spreading slowly except in milk-borne epidemics when the outbreak affects many persons simultaneously. Low temperature retards dessication and prolongs the life of *Bacillus diphtheriæ*. Coughs tend to spray droplets of infected saliva.

Bacteriology.—The specific cause of diphtheria is a Gram positive, non-motile bacillus, often clubbed in shape, and showing striking parallelism in microscope preparations made from an eighteen-hour culture on blood serum. The bacillus forms no spores and stains readily by usual methods.

Tendency to bi-polar staining is shown with all stains but is best shown by the Ponder method.

In suspected cases a diagnosis may be made from a throat smear in about 25 per cent. of the cases of diphtheria fifteen or eighteen hours before the culture can be pronounced positive. Valuable time thus is gained. This procedure should not be neglected.

Gram positive bacilli are found in the mouth. These usually are large harmless saprophytes. The finding of a *small Gram-positive bacillus* in a throat smear from a suspicious case warrants immediate isolation. *Bacillus diphtheriæ* is easily killed and does not readily withstand heat or drying. It is killed in ten minutes at temperature 122° to 136°F.

Period of Incubation.—The period of incubation is from two to seven days.

Mode of Transmission:

1. By contact with a person infected with diphtheria;
2. By droplet infection;
3. By articles soiled with diphtheritic membrane;
4. By pet animals;
5. By milk;
6. On board ship where conditions of temperature and humidity favor survival of the organism it is highly probable that the dish cloths, which are none too frequently boiled, are an important factor in disseminating the disease from one piece of infected mess gear to another.

Handling an Outbreak.—When a case of diphtheria develops on board ship the individual should be given antitoxin and isolated at once. All contacts should be isolated if practicable. Usually this cannot be done. There is a point at which theory and practice must agree upon a rational *modus vivendi.*

If a diphtheria case should develop in room 1152 of a big hotel, the infected individual would be moved out and the room disinfected. Quarantine of the hotel would not be considered. Aboard ship similar line of action should be followed. Visiting parties to and from the ship should be discouraged but the normal activities of the ship should not be disturbed.

The mess gear should be thoroughly boiled and the drinking terminals at the scuttle-butt should be flamed at least once daily with a gasolene torch. Cuspidors all over the ship should be boiled.

Divisional officers should be instructed to direct any man feeling sick, especially if the throat is sore, to report for examination at once.

If other cases develop the ship should be placed in close quarantine, and when practicable should proceed to the nearest port where facilities will be available:

(*a*) For transfer of sick to hospital;
(*b*) For obtaining antitoxin to meet needs;
(*c*) For complete disinfection;
(*d*) For opportunity to send the crew into camp or barracks ashore.

The throats of all hands should be inspected daily and all should be given an antiseptic gargle. This should occur at an hour when a minimum of interference with ship's activities will result. The best

time is just before the noon meal because (*a*) the throats are apt to be free of food particles and (*b*) the daylight is bright.

FIG. 131.—Marines in life-preservers in the war zone. They are filing past the point where their mess-gear is immersed in boiling water immediately before receiving their rations.

The examination should be made on deck if weather permits. The medical officer should select a place on deck where there is room for his

work and should take his stand with his face toward or away from the direct rays of the sun, depending upon whether he desires to use a head mirror or direct illumination. He should stand upon a box of convenient height to enable him to *look down* into the throats and also to render him sufficiently conspicuous.

On his extreme right should be stationed a chief pharmacist's mate to check off the members of the crew from a list of billet numbers to be supplied from the executive office.

FIG. 132.—Medical officers inspecting the throats of members of the crew of a battleship during an outbreak of diphtheria.

On his immediate right should stand a hospital corps man whose duty it is to supply the examiner with wooden tongue depressors and to instruct those being examined to open the mouth and say "ah."

On the immediate left should be placed a galvanized iron bucket to receive the wooden tongue depressors after their use. This bucket should be elevated to the level of the examiner's waist. If the examiner is on deck the saliva-soiled tongue depressor may be carried by the wind and may fall to the deck instead of into the bucket. A hospital corps

man with pencil and paper should stand here ready to take the name of any man whose throat requires further examination. To the left of the bucket should be placed a mess table behind which several hospital corps men can stand and fill paper cups with the antiseptic gargle. To the left of the mess table should be two immersion tubs (from a handling room) into which the gargle may be spat after gargling. Ten men easily may stand around each tub to gargle.

Finally, a large receptacle should be placed to the left of the immersion tubs to receive the discarded paper cups of the men who have just gargled. The divisions should fall in by billet numbers. These are much more quickly checked off than names. The division marching single file should approach and pass by the examining party, the following being done:

The individual is checked by billet number and examined by the medical officer. A chalk mark on the deck will aid the man in taking his stand in the desired position as he approaches the examiner. Removal of the cap renders the neck more supple as the man will not stiffen his neck to avoid losing his cap.

If the throat appears normal the man passes to the table, gets his gargle, uses it, spits it into the immersion tank, throws the paper cup into the receptacle, and goes his way.

If a throat appears sore, or tonsillar crypts have an exudate, the man is told to fall out and report at the sick bay for further examination.

Coöperation between the administrative authorities and the medical officer will enable continuous examination by the latter, yet the interference with ship's work will be slight.

Unless a careful checking system is adopted the most dangerous man may be overlooked. Feeling sick, he may crawl away and secrete himself, thus missing examination and remaining an undetected menace to others. About 1000 or more sanitary paper cups and as many tongue depressors are needed for each examination. These daily examinations must be continued until the expiration of the period of incubation after the last case has developed; consequently, the medical officer of a battleship should have no hesitancy in making requisition for what may seem a very large supply of culture media, tongue depressors, sanitary paper cups, disinfectants, and materials for preparing gargles. When it is possible to isolate contacts the Schick test should be applied and an immunizing dose of antitoxin, or of the toxin-antitoxin mixture should be administered to all who give a positive Schick reaction.

The results obtained from use of the toxin-antitoxin mixture are said to produce an enduring immunity. Park and Zingher using 1 c.c. toxin-antitoxin mixture at intervals of one week for three weeks produced an immunity which continued for a year and a half, *i.e.*, so long as the cases were under observation. They consider it advisable to start immunization after the first year of life. The immunization acquired by this method is produced slowly; consequently, may not be depended upon in the presence of diphtheria outbreak. The administration of antitoxin to diphtheria contacts in the Navy is regarded as undesirable except perhaps in cases of nurses or attendants who give positive Schick reaction. The immunity acquired as result of administration of antitoxin lasts only about three weeks and sensitizes the body against the horse serum which would have to be given in massive dose should the individual thus immunized develop diphtheria. As result of this sensitization dangerous anaphylactic reaction may develop when the large therapeutic dose is necessary. Those suffering with diphtheria should not be permitted to go out of quarantine until three successive cultures taken at least twenty-four hours apart have shown that their throats and noses are free of diphtheria bacilli.

Even after this precaution, an occasional instance is seen in which diphtheria is conveyed by one who has been pronounced free from the disease after the employment of the usual laboratory safeguards.

An instance illustrating this possibility occurred recently in which an individual showing a positive culture for diphtheria was transferred to an isolation hospital.

He was isolated on the 17th of October and came out of quarantine on the 30th of October, after six successive negative cultures had been taken. After the period of incubation following his return a case of diphtheria developed, and this was followed by six other cases, all from the same squad room.

The laboratory showed that the original case was a carrier of virulent diphtheria bacilli.

Taking the Culture.—A culture should be taken in all cases where there is an exudate on the tonsils or mucous membrane of the throat.

Observance of this rule will save trouble in the end. Diphtheria will be recognized before there has been opportunity for the wide spread of the infection. A culture should be taken before the patient has used an antiseptic gargle. Unless cultures are taken also from the nose the work is but half done.

In smearing the swab over the surface of the blood-serum tube, care should be taken not to exert pressure sufficient to break the surface of the medium. When blood serum is not available, a medium made of mixed yolk and white of egg will serve.

Good results have been obtained by using the surface of a hard-boiled egg, after cutting with a sterile knife and incubating.

Carriers.—It has been estimated that 2 per cent. of individuals harbor the diphtheria bacillus. In times of epidemic the percentage may be increased to 30 or 40 per cent. These healthy carriers are a potent factor in the spread of the disease, in that they present no clinical symptoms, consequently they are not recognized as disease carriers, except perhaps by accident.

Occasionally the bacillus persists for long periods of time in the throats and noses of those who have suffered from the disease.

Unless the throat is clear at the end of four weeks, virulence tests should be made, and if the organisms are found to be non-virulent the individual should be permitted to resume his normal activities.

Milk.—Milk may become infected with the diphtheria bacillus, and be a grave menace to those using it.

An outbreak resulting from infected milk is fulminant in character, a number of cases appearing at the same time. Pasteurization of milk will exclude this article of food as a diphtheria carrier.

The writer has been impressed with the concurrence of diphtheria and Vincent's angina in outbreaks of the former disease. In an outbreak of diphtheria on the U. S. S. North Dakota several cases of Vincent's angina were discovered, all of which were negative for the diphtheria bacillus.

Whooping Cough

Whooping cough is seen occasionally in the naval service and is mentioned because of the large number of young men in the service. While it is a disease of youth I have seen a man sixty-six years old in an attack.

The specific cause is the *Bacillus pertussis* or the Bordet-Gengou bacillus.

Mode of transmission is through articles soiled by the sputum of those sick with the disease or by droplet infection.

Incubation.—The period of incubation is from two to fourteen days.

Immunity.—One attack confers lasting immunity. Hess claims success in using vaccines of *B. pertussis* as a prophylactic.

Prophylaxis.—Patients should be isolated until two weeks after development of the whoop. Contact should be avoided. Disinfection similar to that for other sputum-borne disease should be practised. Whooping cough is a dangerous disease because of the too common bronchitis which complicates it.

German Measles

German measles is very common among the recruits at training stations, and aboard ship. It spreads rapidly, and but for its usual mildness would be a grave problem.

The causative organism of German measles is unknown.

Mode of Transmission.—It is generally assumed to be transmitted by contact (droplet method) or by articles soiled by the sputum of those sick of the disease.

Incubation.—The period of incubation is about ten days.

Immunity.—One attack confers a lasting immunity.

Prophylaxis.—Avoid contact with the disease. Isolate patient for eight days after the onset of the disease, or longer if catarrhal symptoms persist. Disinfection as for sputum-borne disease should be practised.

The disease is mild, but grave broncho-pneumonia may complicate it.

Cerebro-spinal Fever

Cerebro-spinal fever is an acute, infectious disease caused by *Diplococcus intracellularis meningitidis* (Weichselbaum).

Prevalence.—Cerebro-spinal fever is a disease associated with overcrowding. Rosenau refers to it as "a disease of infants and soldiers." It is prevalent in this country and in Europe and appears from time to time in localized outbreaks in various armies of the world, as well as among naval forces. In our Navy from 1906 to 1916 the morbidity rate of cerebro-spinal fever has fluctuated from 0.64 per 1000 in 1907 to 0.028 per 1000 in 1916. This variation appears to be dependent upon the movement of the disease among the civilian population from whom the recruits are drawn rather than any conditions peculiar to the naval service. Recruits coming from foci of infection introduce the

disease into the ship or training station to which they are first sent, and there the essential conditions of the naval service favor spread of the infection. There was a marked increase in the incidence of cerebro-spinal fever following the sudden expansion of the Navy after the declaration of war against Germany. The rapid enlistment caused overcrowding at the training stations and recruits were sent directly to ships without undergoing the usual period of detention and observation required in peace times.

Bacteriology.—The specific cause of cerebro-spinal fever is a Gram-negative diplococcus resembling morphologically the gonococcus. It is often referred to as the "meningococcus." The organism is found in the nasal secretions of patients and of healthy carriers. It is believed to invade the system through the nose, and the roof of the nasal pharynx is the common site from which it may be isolated. The organism is found in the pus cells from the cerebro-spinal fluid of patients. The meningococcus has low resistance and soon is destroyed by sunlight and dessication. It dies easily even under laboratory conditions.

Period of Incubation.—At a training camp cerebro-spinal fever was introduced by drafts from a training station. A man ill with the disease was taken from the train upon arrival on December 29.

Only one case developed among the men who were at the camp before the arrival of the draft. This case was the man who took the names of the members of the draft which arrived, *i.e.*, was in close contact with the sick man who arrived on the train December 29. He developed the disease January 7.

In the above-mentioned case a period of incubation between exposure of a man from an uninfected camp to a known case of cerebro-spinal fever appears to have been nine days.

Ten cases occurred among men from this training station.

Healthy Carriers.—Elser and Huntoon have pointed out the rôle of healthy carriers in spreading cerebro-spinal fever. From 40 to 70 per cent. of healthy persons exposed to the disease become carriers and are capable of transmitting it for a period of at least thirty days. It is estimated that there are ten carriers for every case.

On board a ship 7.24 per cent. of carriers were found among a crew of 649. In a training camp 6.45 per cent. were found among 527 persons cultured.

Immunity.—One attack does not confer lasting immunity. The death rate in untreated cases is 70 per cent. There appears little hope

for widespread immunity similar to that which has resulted from measles. Killed cultures of the meningococcus have been employed in an effort to produce immunity. Favorable results have been reported. Immunity is said to be produced one year after the injections; consequently, the method cannot be used for the protection of contacts during an acute outbreak.

Prophylaxis.—In the naval service cultures should be taken of all recruits immediately upon their arrival at training stations or barracks. Recruits should be placed in a detention barracks or camp for a period of three weeks for the dual purpose of obtaining results from cultures of the throat and nasal mucosa and to give abundant time for the development of any infectious disease to which the recruit may have been exposed. If healthy carriers are found, they should not be permitted to join the men in the barracks or to go on board ship until they are no longer carriers. Healthy carriers should receive treatment for the nose and throat with a view to kill the infection. Chloramin solution 0.5 to 1 per cent. in strength is the best agent for this purpose. Other antiseptic gargles and sprays are useful. Despite active treatment, some individuals remain carriers for indefinite periods of time.

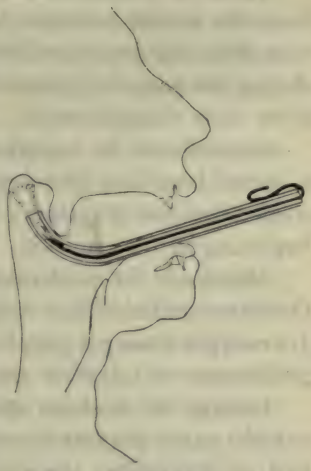


FIG. 133.—Taking a culture from the naso-pharynx. A bent glass tube carries the swab which is thrust out after the glass tube is in position. This avoids infection with organisms in the saliva.

In the presence of an outbreak of the disease, patients should be isolated immediately; all contacts should be placed under observation and should be cultured to detect the carriers. Those attending the patient should be especially careful to avoid proximity to patient during his sneezing or coughing. Respirators should be worn. Discharges from the nose and throat and all articles soiled by them should be thoroughly disinfected. The throats and noses of patients should be treated with antiseptic solutions as gargles or sprays.

Both concurrent and terminal disinfection should be practised. Convalescents should be isolated until four successive cultures taken five days apart show the naso-pharynx to be free from the meningococci.

Measles

Measles is an acute, dangerous, communicable disease, due to a filterable virus, which was discovered by Goldberger and Anderson. Several observers have reported organisms believed to play a causative rôle in the production of measles, but the specific organism has not been discovered.

The period of incubation is fourteen days, rarely eighteen.

Mode of Transmission.—Measles is spread through the secretions from the mouth and nose of infected individuals or by immediate contact with the person suffering from the disease. It is communicable during the period of catarrhal symptoms and possibly for a brief period after their disappearance.

Cases should be regarded as capable of transmitting the disease for a period beginning five days before the eruption and extending to one week after the eruption. The height of infectivity is reached at the beginning of the eruption.

Measles is the most readily communicable of all infectious diseases. One observer found that only 14 per cent. of susceptible children escaped. Its ravages among a people who have not acquired immunity through generations of infection are extremely appalling.

During the measles epidemic in Fiji in 1875 more than 40,000 out of 150,000 persons are said to have died because this isolated people had no immunity, the disease having been unknown in Fiji up to the time of the outbreak.

Aside from the immediate danger caused by measles the dangerous complications which often attend it should cause it to be regarded as a highly fatal disease. The fever with its effect upon the myocardium, the bronchitis, pneumonia, and eye and ear complications, are among its immediate and dangerous by-effects. The lowering of resistance and vitality consequent upon an attack of measles often results in lighting up a latent tuberculous infection.

Prophylaxis.—Among troops and on board ship the appearance of measles should be regarded with much concern. The concentration of men within small space renders inevitable the exposure of many individuals during the period of incubation, and if these "contacts" are non-immune, the appearance of the disease in epidemic form is to be expected.

When measles appears it should be isolated immediately, and

all known contacts should be isolated also until the expiration of the period of incubation, namely fourteen days. The effects of the sick man should be disinfected at once; this includes clothing, bedding, mess gear, and especially handkerchiefs.

In 1901–1902, Medical Director H. G. Beyer, U. S. Navy, demonstrated that measles can be controlled by rigorous quarantine and antiseptic precautions when he had an outbreak of measles on a training ship and the complement consisted mainly of young and susceptible adults.

Recently Colonel E. L. Munson of the U. S. Army Medical Corps has confirmed Beyer's observations by demonstrating the absolute control of a measles epidemic when rigorous measures are applied along rational lines.

This demonstration occurred among the troops on the Mexican border, and while the disease was stamped out of the military organizations in which it appeared, it persisted among the civilian population in the vicinage of the camps.

Upon the appearance of the disease and isolation of the patient and of the contacts, all members of the command should be kept under close observation. They should be inspected by the medical officer daily, preferably morning and evening. Those having fever should be isolated at once, and the buccal mucosa should be carefully examined for the appearance of Koplik spots. Coryza, conjunctivitis, skin eruption or bronchitis should be sufficient to place an individual in isolation for observation, as these catarrhal symptoms probably are prodromal.

Nurses and hospital corps men attendant upon measles should be selected from those who give a history of the disease themselves, and who reasonably may be supposed to possess an acquired immunity. Everything which comes in contact with the patient should be carefully disinfected. This applies especially to mess gear, handkerchiefs, and discharges from the mouth and nose.

The room should be kept dark to prevent the patient from undue eye strain during the period of conjunctival irritation. The nasal-pharynx should be treated with some antiseptic solution with a view to prevent extension of infectious secretions to the eustachian tube and consequent suppurative disease of the middle ear. Chilling should be avoided in order to prevent a further predisposition to pulmonary

infections. Upon recovery individuals should take an antiseptic bath —bichloride of mercury 1 to 1000 or carbolic acid 1 per cent.

Hair, finger nails, and toe nails should be carefully disinfected. Nose and mouth should be treated with an antiseptic solution and the external auditory canal should be washed out with 70 per cent. alcohol. The individual should then be dressed in freshly disinfected clothing before being permitted to mingle with other members of the command.

Scarlet Fever

Scarlet fever is an acute communicable disease characterized by high fever, angina, an exanthem, and frequently by serious complications. The period of incubation is "from one to seven days, oftenest from two to four" (Osler). McCollam states that the average period is ten to fourteen days. The latter figures are regarded as extreme, those quoted by Osler being more nearly in accordance with the writer's experience. Scarlet fever is rare in tropical countries.

Bacteriology.—The specific cause of scarlet fever is not known. Several organisms have been described, yet none has received sufficient confirmation of its specificity to be accepted as the cause.

A Gram-positive "Bacillus scarlatinæ" has been described by Mallory and Medlar, who regard it as the cause of scarlet fever. This organism is said to be found in the tonsils or about them. A protozoön found in blisters on the skin of scarlet-fever patients has been regarded as cause. Other workers describe a "Diplococcus scarlatinæ" which they claim to have found in the urine, blood, desquamated epithelium, and throat.

Regardless of the claims made for the several organisms above mentioned there is general agreement that *Streptococcus pyogenes* is commonly found in joint complications and throat, some pathologists believing it to be the specific cause of scarlet fever.

Immunity.—One attack usually confers lasting immunity, although individuals are seen who have experienced two or more attacks. Since the specific cause is not known methods of producing artificial immunity have been unsuccessful.

Although scarlet fever is regarded as a disease of children, adults often are attacked. Out of 166,000 cases, 11 per cent. were past the age of sixty years.

Scarlet fever is a highly fatal disease in children under ten years of age, 92 per cent. of the deaths from the disease being in this age group.

Mode of Infection.—1. *Contact.*—Scarlet fever is spread by contact with persons having the disease. It is not so contagious as measles. Often only one or two cases will appear among a ship's company.

2. *Milk.*—Numerous instances are on record to show the transmission of scarlet fever by milk. It is said that cows may transmit the disease. Kober has studied ninety-nine milk-borne outbreaks of scarlet fever, and in sixty-eight of the number he found that scarlet fever was prevalent either at the dairy or farm from which milk was being supplied.

3. *Fomites.*—Clothing or articles such as books, toys, etc., soiled by the discharges from nose or throat of scarlet-fever patients may be infectious. In this connection transmission of the disease by a third person should be remembered.

Osler mentions a case in which no other mode of infection was probable, and considered himself as the carrier in that instance. When the specific cause is known healthy carriers undoubtedly will be demonstrated. The specific virus appears to be inhaled into the throat, taken with the food (milk), and the disease appears transmissible through the blood, as children are born with scarlet fever.

Wounds appear to be a predisposing cause. The incidence of the disease among women after childbirth is more than coincidence.

Scarlet fever has been communicated to monkeys by swabbing their throats with material from the throats of scarlet-fever patients.

Quarantine.—Persons sick of scarlet fever should be isolated immediately and contacts constantly watched for throat symptoms, fever or eruption. The quarantine should last for a period of eight weeks, unless the nasal and throat symptoms have entirely disappeared and desquamation has ceased.

Out of a group of 3800 cases 79 had been infected by persons returned from hospitals after treatment for scarlet fever. These "return cases" indicate need for close quarantine and careful disinfection of persons who have had the disease.

Prophylaxis.—Isolate at once. Watch contacts carefully. Their throats should be inspected, temperature taken daily, and any sore throat or fever should receive prompt attention. Non-immunes who are in contact with scarlet fever should use an antiseptic throat gargle. All mess gear and linen should be sterilized. All articles handled by the patient should be disinfected as should be bath water and dejecta.

During the course of the disease the patient's skin should be kept anointed with vaseline or some bland ointment to prevent the blowing about of scales.

When the patient is to be taken out of isolation he should be given an antiseptic bath with a view to disinfect the epithelial structures thoroughly. Finger and toe nails should be cut and thoroughly cleaned, the hair and entire body should receive an antiseptic bath; special attention being given to the umbilicus. The external auditory canal should be disinfected with alcohol, and the nose and throat should be thoroughly cleansed with an antiseptic gargle.

Smallpox

Smallpox is an acute, communicable, highly fatal, and directly preventable disease.

Prevalence.—Owing to neglect of vaccination in some sections and half-hearted enforcement of compulsory vaccination in other sections, smallpox appears frequently in our country.

Although it is regarded as a type of the most contagious disease and although the naval forces of the United States are serving in every quarter of the globe where smallpox is endemic, compulsory vaccination upon enlistment has made smallpox a clinical curiosity in the Navy.

Period of incubation is twelve to fourteen days.

Etiology.—Various workers have attributed a causative rôle to organisms both animal and vegetable discovered by them. The cause remains unknown.

Immunity.—One attack of the disease confers lasting immunity. Vaccination with cowpox virus produces an immunity which lasts for several years. In the United States Navy vaccination is compulsory upon enlistment and each re-enlistment. In the presence of an epidemic of smallpox or in case of contact, re-vaccination should be practised regardless of dates of previous vaccination.

Prophylaxis.—Vaccination prevents smallpox. Thoroughly vaccinated individuals will not contract the disease. Medical officers should satisfy themselves that all persons under their charge are protected by vaccination. If a case should develop it should be placed immediately in an isolation hospital or camp. Contacts should be vaccinated and isolated for observation. Scrupulously thorough concurrent and terminal disinfection should be practised. Before the

patient is permitted to return to duty his entire body should be entirely shaved; eyes, nose, and mouth treated thoroughly with antiseptic solutions, ears and umbilicus should be washed out with alcohol, and after this the patient should be given an antiseptic bath, special attention being paid to the paring and cleansing of finger and toe nails. During the course of the disease the place of isolation should be thoroughly screened against insects and vermin.

Chicken-pox

Chicken-pox is an acute communicable disease commonly contracted in childhood, yet no age is exempt.

It is usually regarded as a trivial affection. After the formation of the vesicles, infection may occur, the complication giving a grave aspect to a disease which ordinarily is mild. Since the course of the disease is mild, children should be kept from school, but there seems little reason for isolation of contacts. In the military service the writer is of the opinion that it is scarcely worth while to isolate cases of chicken-pox.

The possibility of confusion of diagnosis resulting in non-recognition of a case of smallpox, makes isolation seem worth while, not because chicken-pox is a serious disease, but **because smallpox may be mistaken for it**.

The Period of Incubation.—The period of incubation of chicken-pox is fourteen days. The writer knows of no disease in which the period of incubation varies so little.

Bacteriology.—The specific organism causing chicken-pox has not been discovered. Certain cell inclusions have been observed, and they are regarded by some as pathognomonic of chicken-pox.

Immunity.—One attack confers a lasting immunity. The disease is of such mild character that artifical immunization is unnecessary.

Prophylaxis.—The prevention of chicken-pox lies in the avoidance of contacts. The mode of transmission is unknown but it seems probable that the disease is communicated by droplet infection. Susceptible persons should avoid contact with cases of chicken-pox. The mess gear and linen of chicken-pox patient should be disinfected. The lesions should not be irritated or disturbed as each is a potential source of adventitious infection. The height of infectivity is during the eruptive stage, therefore early diagnosis and isolation are desirable among

children if not among adults. Individuals should be released from isolation after the crusts have dropped off. It is not known whether chicken-pox is transmissible by fomites, nor is it known whether healthy carriers spread the disease.

Mumps

Mumps is an acute communicable disease the specific germ cause of which is unknown. The disease is believed to be communicated by contact with one suffering from mumps and with articles recently soiled with oral or nasal secretions of the infected person. Experience leads the writer to feel that healthy carriers of the disease exist, yet this cannot be proved until the specific germ is recognizable.

Period of Incubation.—The period of incubation is about fourteen days. Four to twenty-five days are the extremes. Mumps is said to be communicable for a period of at least six weeks. It is not clear upon what this assumption is based. The infected individual should be regarded as capable of transmitting the disease during the period of swelling of the parotid and submaxillary glands.

Mumps is a common disease among children and often is met in epidemic form at training stations or on board ship where many susceptible young adults are so closely crowded that contact with many persons is inevitable during the period of incubation of the first case.

Mumps usually is a harmless if painful disease, and experience causes the writer to feel that the isolation on board ship and in training stations is barely if worth while. Every prophylactic measure is urged in civil life. In military life it seems desirable that this uncomfortable disease should be had early in order to acquire the immunity which an attack confers, then the individual will no longer be susceptible. The discomfort is no greater than that produced by the indispensable vaccination against smallpox. The danger is nil, and the individual will be protected against possible incapacity from the mumps in time of national need.

While the U. S. Naval forces were occupying Vera Cruz, Mexico, in 1914, I treated a battalion commander who was ingloriously driven from the field of battle by mumps!

Early diagnosis is desirable, especially if isolation and observation of contacts are to be practised. Non-immune contacts should be kept from public gatherings for at least two weeks after exposure.

There is no necessity for terminal disinfection but scrupulous care should be exercised in the execution of concurrent disinfection. Secretions from the mouth and nose, all articles soiled by them, and especially mess gear, should be carefully disinfected.

No method of artificial immunization is known, but the immunity conferred by an attack of mumps appears to be permanent.

Pneumonia

Pneumonia is an acute infectious disease due to the *Pneumococcus*.

Bacteriology.—The *Pneumococcus* is a Gram-positive, non-motile, non-spore-bearing, lance-shaped diplococcus which grows best on blood serum, coagulates litmus milk, and forms acid in inulin media. It causes more than 80 per cent. of the cases of pneumonia (Stitt) whether it be of the croupous, catarrhal or septic type.

Four types of the *Pneumococcus* have been isolated, the types reacting specifically with their homologous immune sera.

Of the four types, type I and type II cause 64 per cent. of the cases of pneumonia. The mortality for these groups is 57 per cent. (Avery, Chickering, Cole and Dochez).

Type III, sometimes called *Pneumococcus mucosus* because of the sticky exudate which it forms, is highly fatal. The mortality is variously placed from 50 to 100 per cent. This group is responsible for 10 to 12 per cent. of the cases of pneumonia.

Type IV embraces strains of pneumococci not embraced in the above-mentioned types. About 25 per cent. of cases of acute lobar pneumonia are produced by this type. The mortality rate is placed at about 10 per cent. Most of the pneumococci found in mouths during health belong to type IV. Of 450 normal individuals harboring pneumococci type IV claimed 345.

Types I and II seldom are found in the mouths of healthy individuals unless they have been in intimate association with pneumonia of these types. Of 68 cases of lobar pneumonia recently investigated at the Naval Hospital, Chelsea, Massachusetts, 13 were due to type I, 6 to type II, 4 to type III, 23 to type IV, and 22 were "not typed."

Identification of the type in a given case is of utmost importance. If the disease be due to type I, a serum of high potency prepared from this type may be administered. Of 103 cases caused by type I the serum treatment at the Rockefeller Institute has shown but eight

deaths. Serum therapy has been unsatisfactory in types II, III, and IV.

Mode of Transmission.—Pneumonia is a sputum-borne disease (droplet infection). It seems that dried sputum readily may cause the disease. From 175 specimens of dust from houses which had contained pneumonia due to types I or II, 73 specimens showed pneumococci, and of this number 47 belonged to types I or II (Cole).

Prevalence.—In the United States Navy the morbidity rate for pneumonia in 1915 was 4.23 per 1000, and in 1916 was 3.82 per 1000.

Immunity.—One attack does not confer lasting immunity but predisposes to a second attack. Immunization by means of sera has been disappointing. It is possible that preventive inoculation may be tried among troops with hope of success.

Prophylaxis.—Careful concurrent and terminal disinfection should be practised. Pneumonia cases should be isolated and treated as other infectious diseases. Particular care should be given to washing the walls and floors of rooms occupied by pneumonia patients with disinfecting solutions. The convalescents must be regarded as healthy carriers although the organisms belonging to types I and II die out in their mouths within a few weeks. The longest period in which the organisms have been observed to persist in the mouth of a convalescent has been eighty-three days. Type I disappears from the dust within three or four weeks.

Disinfection of Pneumococcus Carriers.—Avery, Chickering, Cole and Dochez found 12 per cent. of healthy persons who were in contact with lobar pneumonia due to pneumococci of types I and II carried pneumococci of the type with which they were in contact.

The same observers found these types in only 0.3 per cent. of healthy persons who had not been in contact with lobar pneumonia.

Healthy carriers exist as well as convalescent carriers. (Convalescents carry the bacilli three or four weeks.) All persons in contact with lobar pneumonia and all convalescents from the disease should use an antiseptic gargle such as Dobell's solution.

Kolmer and Steinfield recommend:

Ethylhydrocuprein hydrochloride	0.005
Liquor thymolis	5.000
Aq. Dist. ad	50.000

Quinine bisulphate or quinine hydrobromide may be used in 1 to

10,000 dilution with good result The ethylhydrocuprein hydrochloride may be used twice daily without any ill effect from such small quantity as might be swallowed during the gargle.

Tuberculosis

Bacteriology.—The tubercle bacillus, discovered by Koch in 1882 is a Gram-positive, acid-fast bacillus 3 microns long and very narrow.

Tubercle bacilli produce tuberculosis in man, cattle, birds and fish. The bovine type may produce the disease in man and the human type infects cattle. The avian and the fish types are of little importance to man. Pulmonary tuberculosis in man usually is due to the human type, while the bovine type causes many of the glandular, bone and skin lesions. About 7 per cent. of tuberculosis in man is of the bovine type.

The average admission rate for tuberculosis in the U. S. Navy for the past ten years has been 4.89 per 1000. For the past three years it has caused a greater number of sick days than any other disease, and more than 10 per cent. of the deaths in the naval service are due to tuberculosis.

Modes of Infection.—Three principal modes of infection are recognized:

(*a*) The ingestion method;
(*b*) The inhalation method;
(*c*) The droplet method.

(*a*) The *ingestion theory* has the support of most investigators who hold that infection usually occurs early in life, remains latent, and becomes active under conditions favorable for its development. The bacillus may be carried on to food by vermin or insects. It survives in cool water for a year, hence infection through water polluted by dejecta or sputa of persons having tuberculosis may be a factor. Whether taken with food or as dust swallowed the primary lesions are glandular and a suitable exciting cause may light up a systemic infection.

(*b*) The *inhalation method* is important for the reasons that bacilli may be inhaled, then swallowed, or may ultimately reach the lungs by inhalation. The bacillus may remain alive for months in dried sputum provided sunlight does not gain access to and disinfect it.

(*c*) The *droplet method* of contact infection must be more seriously considered aboard ship than it is ashore.

Aboard ship the contact is closer, the per capita air volume smaller, the dilution of expired air is less, and temperature, moisture and darkness between decks favor the life of the bacillus which is sprayed into the air.

Predisposing Causes.—Youth, hereditary weakness, overwork, exposure, vicious habits, infectious diseases, respiratory diseases, and poverty are predisposing causes. Any deviation below the standard height and weight for age should excite suspicion.

Immunity.—Bitzke of Berlin states 58 per cent. of autopsies show past or present tuberculous lesions. This is the lowest estimate made; other observers place the percentage at 90 or above.

Accepting 58 per cent. of all autopsies as showing tuberculosis and remembering that 12 per cent. of the German people die of tuberculosis it would appear that 46 per cent. of those who die must possess considerable immunity to tuberculosis, else they would have succumbed to the infection which failed to cause the death.

Probably the infections early in life produce immunity. Most persons over five years of age will give a positive Von Pirquet reaction.

No race is immune. The negro race appears more susceptible than the white, but the greater ignorance and poverty among negroes may account for their apparently greater susceptibility.

Prophylaxis.—Reject all applicants for enlistment who present suspicious physical signs, symptoms or history. Accept none who fall below the standards of weight and height for age.

The medical officer should examine any of the crew who upon inspections appear to be under par.

Members of the crew who cough, especially at night, should be located and examined. Prolonged "colds" should be carefully watched, the sputum being examined from time to time.

Early Diagnosis is the Keynote of Prophylaxis.—If the disease develops aboard ship the victim should be isolated (so long as *B. tuberculosis* is being given off by him), on deck if the weather will permit, and sent out of the ship at the earliest possible moment. His mess gear should not be used by others and should be boiled after each use. His sputum should be received in paper sputum cups or in gauze and burned. All articles soiled by sputum, nasal discharges or feces should be burned or disinfected. He should be cautioned concerning danger to others. After his transfer from the ship the space occupied by him should be thoroughly disinfected.

Associates of the tuberculous man should be watched carefully for symptoms of infection.

Anti-spitting regulations should be enforced rigorously aboard ship. Men should be taught the danger of spitting.

Automatically flushing cuspidor-urinals should be conveniently placed for access by the crew.

Everything should be done to improve the health and increase the resistance of the crew.

One who has had tuberculosis should never be permitted to return to duty aboard ship.

It is said that more than 150,000 men have been invalided home from the French Army (Biggs, 1916) because of tuberculosis. Our own men serving in France will do well to remember that the tubercle bacillus may live long in water and that trench infections may occur.

Malaria

Malaria is caused by animal parasites belonging to the Hæmosporidia. These Hæmamœbæ enter the red cells, produce pigment, and possess amœboid movement.

The characteristic paroxysms of malaria are due to the rupture of the merocyte in the blood, the toxin producing chill, fever, and sweat.

Tertian malaria, caused by *Plasmodium vivax*, is so called because the rupture of merocytes of this organism occurs every third day.

Quartan malaria is caused by *Plasmodium malariæ*. The merocytes of this parasite rupture and produce malarial paroxysms every fourth day, hence the name "Quartan."

Aestivo-autumnal malaria is caused by *Plasmodium falciparum*.

Laveran discovered the cause of malaria and Ross discovered that the organism is transmitted by the mosquito (1895). His observations have received fullest confirmation.

The epoch-making work of Theobald Smith had blazed the trail for the work of Ross.

Smith discovered that Texas fever of cattle is a malarial-like disease caused by a blood parasite. He further discovered that this parasite was transmitted by the cattle tick as an intermediate host. These observations laid the foundation for the study of insect-borne diseases and for the brilliant discoveries which have followed.

Transmission.—Malaria is transmitted from man to man by the Anophelinæ, a sub-family of the Culicidæ. At least 25 per cent. of the anopheline mosquitoes are known to transmit malaria.

The female of the species alone is capable of infecting man. She feeds upon blood of a malarial patient, becomes infected, the parasites develop and the mosquito after a lapse of twelve days becomes capable of infecting man. "The parasite will not develop in the mosquito when the mean temperature is below 60°F." (Rosenau).

The male feeds upon plants, fruits, and flowers. The Anophelinæ are large brown mosquitoes. In resting position they assume an attitude which places their long axis at an angle of 45 degrees to the surface on which it stands. Stitt has aptly compared it to a bradawl.

Both sexes have palpi as long or longer than the proboscis.

The Anophelinæ breed in pools or stagnant water, are nocturnal feeders, and live in the open rather than in houses.

Immunity.—Individuals may carry a malarial infection without showing symptoms until concurrent illness, injury, or lowering of resistance enables the development of paroxysms.

It is not uncommon in the naval service to see an individual infected in the tropics and "cured" develop malaria upon reaching a cooler climate. One attack of malaria predisposes to another.

Prophylaxis.—In malarial districts ships lying alongside the dock should be screened. This seems next to impossible, but the writer has seen it efficiently done on a dreadnaught battleship.

Screens should be made of copper wire cloth eighteen strands to the inch. This reduces the actual area of any screened opening by 33⅓ per cent. but the reduction in fresh-air intake is compensated for by increased comfort and safety.

If the ship lies a mile from the shore she is apt to remain free of mosquitoes, except such as come on the clothing and the market boats or bumboats.

If the ship's battalion must land each man should carry his mosquito net and use it. In addition, if in the face of an enemy, or if the landing is only for a very brief time, 5 grains of quinine per day should be given to each man.

This practice has the disadvantage of masking a possible infection and making its diagnosis difficult.

A camp should be established to windward of marshes where mosquitoes breed, and away from collections of infected natives.

FIG. 134.—*Anopheles maculipennis* (*quadrimaculatus*), male. (*After Castellani and Chalmers.*) From P. H. Reports.

FIG. 135.—*Aëdes calopus*, male (*Stegomyia calopus*). From P. H. Reports.

FIG. 136.—*Anopheles maculipennis* (*quadrimaculatus*), female. (*Castellani and Chalmers, after Austen.*) From P. H. Reports.

FIG. 137.—*Aëdes calopus*, female (*Stegomyia calopus*). From P. H. Reports.

If a site is to be occupied sufficiently long to warrant it the area should be drained to prevent mosquitoes breeding.

Tin cans and old bottles should be buried. No unscreened containers should be allowed to hold water. Sagging gutters should be lined up or punctured at the most dependent point so water cannot stand in them.

In the tropics bamboo posts are used for fences. The cups left on top of these posts as result of cutting between the joints may furnish unnoticed breeding places right under one's nose. Cavities in forks of trees or as result of decay of trees should be filled with cement, or with earth. Trees should be cleared away as much as possible.

Commonly in the tropics the legs of a cupboard or ice box are placed in basins of water to prevent ants from having access to food.

FIG. 138.—Resting posture of mosquitoes: 1 and 2, *Anopheles*; 3. *Culex pipiens*. (*After Sambon.*) From P. H. Reports.

The writer has found mosquitoes breeding freely in such basins inside a thoroughly screened house.

Personal Prophylaxis.—Unnecessary exposure at night on shore should be avoided in malarial districts. Gloves should be worn. Sentries should be supplied with head nets. Screened sentry boxes should be used when practicable. The writer has seen them prove a godsend in one instance. The ankles should be protected by high shoes and leggins.

Men should sleep under mosquito nets. The nets should be well tucked in all around the cot to keep mosquitoes out.

The watch should be instructed to see that sleeping men have not thrust an arm or leg up against the net where a mosquito may alight and thrust a hungry proboscis through the net.

Volatile oils, *e.g.*, citronella, pennyroyal, lavender, and the like serve temporarily to repel the mosquito. Smudges may be burned about a camp as repellants. The insecticidal fumigants (sulphur,

hydrocyanic acid) may be used in enclosed houses to kill the insects. Pyrethrum is little better than useless. It is not insecticidal, but does intoxicate the insects temporarily. All ditches, drains and pools should be sprinkled weekly with crude oil.

Typhoid Fever

Typhoid fever is an acute, communicable disease resulting from systemic invasion by *Bacillus typhosus*. Typhoid fever has been a scourge of military and naval forces, especially in war time, until within the past ten years, when the prophylactic inoculations, which are now compulsory in the U. S. Army and Navy, have practically abolished this disease among military and naval forces employing the prophylactic.

Bacteriology.—*Bacillus typhosus* is a Gram-negative, actively motile, short, thick, flagellated bacillus.

It does not coagulate milk and produces no gas in lactose or glucose bouillon. Neutral red is not reduced.

B. typhosus invades the body through the mouth and appears to enter the blood through the tonsil or lymphoid structure elsewhere along the alimentary tract.

It may appear in the feces before the fever commences, and may be cultured from the urine in the second, third or fourth week. It appears in the cultures from the blood in 90 per cent. of the cases (Kayser) during the first week.

Urine and feces should be plated out upon Endo's medium. This method gives best results, if blood culture is negative, and is without equal in search for carriers.

Like other filth diseases, typhoid fever is conveyed in food and drink which has become polluted by the excreta or secretions of persons afflicted with the disease or of individuals who have suffered from the disease, have recovered, and are healthy carriers capable of transmitting the affection to others. It is estimated that 25 per cent. of healthy carriers have never had a recognized attack of typhoid fever. The crowded conditions which prevail on board ship are very favorable for the transfer of filth diseases.

Prophylaxis.—The following statistics taken from the annual report of the Surgeon General, U. S. Navy, 1917, show the number of admissions and deaths from this disease during the past seventeen years:

STATISTICS ON TYPHOID FEVER FROM 1900 TO 1916, INCLUSIVE, GIVING ADMISSIONS, DEATHS, AND COMMENT ON DEATHS SINCE PROPHYLAXIS BEGAN IN (FEBRUARY) 1912

Year	Admissions	Deaths	Year	Admissions	Deaths
1900	175	25	1909	191	16
1901	105	14	1910	194	9
1902	125	13	1911	222	15
1903	188	20	1912[1]	57	2
1904	194	19	1913[2]	22	4
1905	172	10	1914	13	1
1906	230	14	1915[3]	18	0
1907	249	16	1916	17	0
1908	176	10			

From the practical viewpoint compulsory inoculation has almost completely abolished this disease. The immunity appears to decrease about 50 per cent. during the first year after the inoculation, and at the end of the second year is practically nil.

All persons should receive the prophylactic upon appointment or enlistment in the naval service. The inoculation should be repeated each successive enlistment. Those past forty-five years of age may be exempted, as may those whose official health records give history of a bona fide attack of typhoid. Troops operating in the field should have compulsory inoculation once every two years.

Formerly the prophylactic was specific for typhoid fever alone. Those immunized by it remained susceptible to paratyphoid whether caused by *Bacillus paratyphosus "A" or "B."* Recently the U. S. Army and Navy have adopted a mixed emulsion called "The Triple Vaccine." It takes its name from the fact that it is made from killed broth cultures of *Bacillus typhosus*, *Bacillus paratyphosus "A"* and *Bacillus paratyphosus "B."* Immunization against these three organisms may be effected by the use of "Triple Vaccine," whereas

[1] Prophylaxis began in February of this year. Of the deaths one was a case that had received no prophylactic treatment.

[2] Of the four deaths only one case had received the full protective treatment. One had received none. Two cases had had only the first injection.

[3] All injections given.

Compulsory prophylactic injections were begun in February, 1912. During 1912 and the subsequent four years there have been only seven deaths in the Navy from typhoid fever. For 1915 and 1916 there were no deaths.

the emulsion of dead typhoid bacilli formerly used afforded protection against typhoid alone. The results obtained after the use of the "Triple Vaccine" have been gratifying.

The **prophylactic inoculation** as practised in the U. S. Navy consists in the administration of three hypodermic injections of an emulsion of dead typhoid bacilli and dead paratyphoid bacilli "A" and "B," *i.e.*, killed broth cultures. The first injection, 0.5 c.c., contains five hundred million dead organisms. The second dose, given ten days later, contains one billion organisms, and the last dose given after another ten-day interval also contains one billion dead organisms.

The **site of the injections** commonly has been at the insertion of the deltoid muscle. This site is exposed to injury during the day, and during the night the tender arm may be rolled upon. It is recommended that the injections be given subcutaneously in the infraclavicular region. The site should be painted with tincture of iodine before and after the injection, which should be placed sufficiently near to the midline of the thorax to avoid pressure which would result from the wearing of suspenders. The injections should be subcutaneous, not intramuscular. Severe reactions have followed the rapid absorption consequent upon injection of the prophylactic into muscle. It is dangerous.

The hypodermic syringe should be thoroughly sterilized before being used. For this purpose Lelean recommends drawing into the barrel oil heated to 130°C. The barrel should be allowed to cool before filling with the emulsion, else the potency of the emulsion may be diminished or lost.

Patients having fever or other evidence of indisposition should not be inoculated. There is no contraindication to the administration of the anti-typhoid vaccine and vaccination against smallpox at the same time. After administration of the anti-typhoid prophylactic the individual should not indulge in alcoholic drink or much physical exercise. Experience has shown it is best to give the injections in the afternoon after 4 o'clock. By doing this the resulting reaction occurs during the night, generally is over by morning, and interferes little with either the patient's sleep or his activities on the following day. A severe reaction is met in about 1 per cent. of the cases. A slightly greater percentage will require to be excused the day following the inoculation, but the large majority will be fit for duty on the morning following inoculation.

Despite the wonderful results which have been achieved by prophy-

lactic inoculations **other efforts at prophylaxis should not be relaxed,** for even in units where complete compulsory prophylaxis has been practised some susceptible individual may be found.

Drinking-water supplies should be safeguarded against pollution and milk should be pasteurized, raw oysters should not be served, and raw vegetables, such as water cress from suspicious sources, should not be used as food, especially by a military unit such as a battleship's crew.

Medical officers should instruct the crew to wash their hands after defecation or urination and before each meal.

Those connected with the cooking and serving of food should be examined with a view to eliminate typhoid carriers.

If typhoid fever is suspected the patient should be isolated at once in a room screened against flies. A positive Widal reaction is of little diagnostic value as it will be found in nearly all persons who have received the anti-typhoid inoculation. A blood culture should be taken at the earliest possible moment with a view to establish definite diagnosis. Visitors should be prohibited. Mess gear should be boiled after each meal, special care being given to the destruction or disinfection of food left by the patient after meals. It should not be left where it may be eaten by others. All linen and bedding should be thoroughly disinfected, as should the patient's clothing. The dejecta should be thoroughly disinfected with chlorinated lime, with 5 per cent. carbolic acid solution, or destroyed by burning or boiling. The patient's bath water should be disinfected before it is permitted to enter the drain pipes of the ship or the sewer.

Should a patient be so unfortunate as to have an abscess or bed sores the dressings should be destroyed by burning. Gauze or paper handkerchiefs should be used by the patient and burned after use. Ice bags and any other articles used in the treatment should be thoroughly disinfected after each use.

Newspapers, magazines or any other articles handled by the patient should be disinfected or destroyed.

Upon convalescence the patient should not be liberated from quarantine for duty among fighting units until laboratory examinations have shown that typhoid bacilli are no longer found in the urine and feces.

Ancylostomiasis

Ancylostomiasis is a widespread disease in the tropics and subtropics, due to:

(*a*) *Necator americanus*;

(*b*) *Ancylostoma duodenale*.

The former is the cause of the infection common in the United States, while the latter is called the Old World species because it is the type usually found outside the United States.

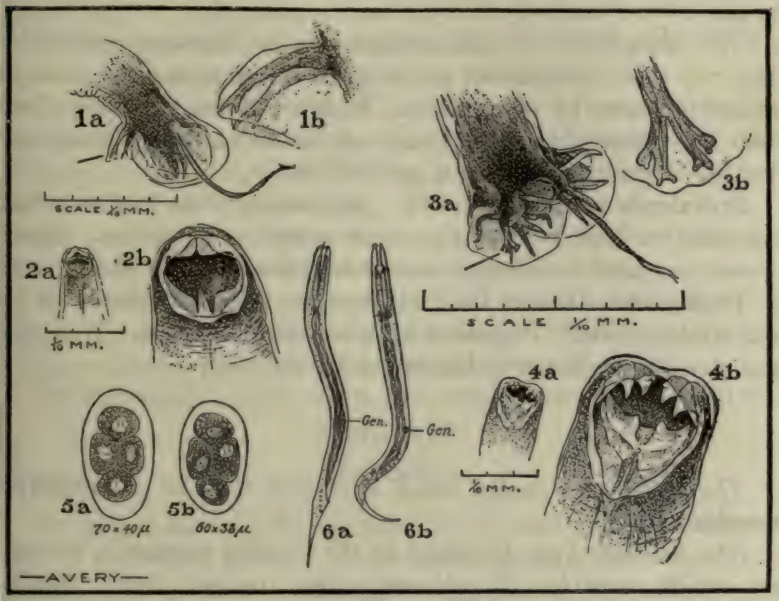


FIG. 139.—1a, Copulatory bursa of *Necator americanus*, showing the deep cleft dividing the branches of the dorsal ray and the bipartite tips of the branches; also showing the fusion of the spicules to terminate in a single barb. Scale 1/10 mm. 1b, Branches of dorsal ray magnified. 2a, The buccal capsule of *N. americanus*. 2b, The same magnified. 3a, Copulatory bursa of *Ancylostoma duodenale*, showing shallow clefts between branches of the dorsal ray and the tridigitate terminations. Spicules hair-like. 3b, The dorsal ray magnified. 4a, The buccal capsule of *A. duodenale*, showing the much larger mouth opening and the prominent hook-like ventral teeth. 4b, The same magnified. 5a, Egg of *N. americanus*. 5b, Egg of *A. duodenale*. 6a, Rhabditiform larva of *Strongyloides* as seen in fresh fæces. 6b, Rhabditiform larva of hookworm in fæces eight to twelve hours after passage of stool. (*From Stitt.*)

The females are ½ inch long and have a pointed tail. The males are ⅓ inch in length and the tail is expanded somewhat like an umbrella.

Both species infect and affect man alike. Diagnosis, treatment and prophylaxis are similar for the two species.

Life History.—The female is extremely fertile. She lays an enormous number of eggs as she hangs to the mucous surface of the human intestine. The eggs escape with the feces of the host. If the climate is warm or if the feces are deposited in tunnels or mines where there is the moisture and warmth necessary to development of the ova, they soon (in twenty-four hours) are ruptured by the mature embryos, or larvæ.

The larvæ live in the soil and bore into the human skin with which they may come into contact (90 per cent. of infections occur thus, the remainder enter by the mouth). Within the body the larvæ make their way ultimately to the jejunum of the host and commence reproduction of kind, by copulation and oviposition.

Prevalence in the Navy.—Of 3500 recruits from Southern States examined for hook worm, 11 per cent. were found infected. Especial precautions must be taken to prevent infection of soil by these carriers.

Prophylaxis.—Detect and treat carriers. Prevent pollution of food and drink by feces. Dispose of feces in sanitary manner. Wear shoes and gloves if contact with infected soil is necessary.

Dysentery

The symptom complex called dysentery may be of **bacillary** or **amœbic** origin.

The bacillary type is caused by the *Bacillus dysenteriæ*, an organism which resembles *B. typhosus* in most respects except motility. It is non-motile.

Two strains of *B. dysenteriæ* are recognized:

(*a*) The Shiga-Kruse type;
(*b*) The Flexner-Strong type.

The former does not develop acid in mannite, while the latter does. The Shiga type is the more toxic.

Prevalence.—Bacillary dysentery may appear in epidemic form in the tropical or temperate zones. The writer's observation of the disease in Japan has impressed its fatality and ease of spread in a temperate climate. Bacillary dysentery is especially to be feared among troops or massed men. It spreads rapidly.

Immunity.—One attack appears to confer no lasting immunity. Vaccination has proved unsatisfactory owing to the severe reaction

after administration of killed cultures of *B. dysenteriæ*. A curative serum is used.

Amœbic Dysentery.—Amœbic dysentery is caused by the *Endamœba histolytica*, an animal parasite which is distributed throughout the entire tropical and sub-tropical world.

The parasite enters the body through the mouth, while in the encysted stage of its life history, and produces dysenteric symptoms.

Walker and Sellards have shown that cultural amœbæ, *i.e.*, vegetative forms, are incapable of producing the disease.

Prophylaxis.—Both forms of dysentery may be prevented by disinfection of the alvine discharges of a patient. Disinfection of toilets, bedpans, rectal tubes, linen, bedding, buttocks of patients, and hands of attendants are all necessary.

In presence of an outbreak the carriers of encysted *Endamœba histolytica* or of *B. dysenteriæ* should be isolated and treated.

The hands always should be washed before meals, but special attention should be paid to this during an outbreak. Food and drink should be above suspicion, and should be protected from flies.

Wards, latrines, water closets, etc., should be screened against flies.

Tapeworms

Certain of the cestodes are parasitic for man and are occasionally met in the naval service. Those infecting man are ribbon-shaped worms, some of them quite long and consisting of a *scolex* or head and *proglottides* or segments. These tapeworms are the matured larval forms of animal parasites which begin life in the lower animals. When the eggs are passed from the bowel they gain entrance in some manner or other to the alimentary canal and circulation of animals used as food by man. After getting into the circulation the egg reaches the muscles or viscera and there forms a new *scolex* or tapeworm head, and if man takes one of these heads into his stomach in meat which has been incompletely cooked the *scolex* there develops in the stomach into the tapeworm. This development takes place by the growth of segments or *proglottides* which grow from the head. There are three forms of tapeworm which develop in man.

1. **Tænia Saginata.**—This tapeworm gains entrance to man through eating rare or raw beef. It is the "beef tapeworm." It is the most common in the United States, grows from 12 to 30

feet long, its *scolex* is unarmed, and the *proglottides* crawl; consequently may be mistaken for separate worms.

2. **Tænia Solium, or Hog Tapeworm.**—This is a smaller tapeworm, from 6 to 12 feet in length. Man usually is infected by it through the ingestion of rare or raw pork. The *scolex* has four suckers and 26 hooklets, long and short. Because of these hooklets it is called the "armed" tapeworm. It is not so common in this country as in Europe.

FIG. 140.—Adult and larval stages of cestoda of man. (*From Stitt.*)

3. **Dibothriocephalus Latus.**—This tapeworm is rare in the United States, but common in northern Europe, especially among fish-eating population. Man is infected through the eating of raw or rare fish. This is the largest tapeworm which infects man, and grows from 18 to 32 feet in length. The *scolex* is unarmed and has two grooves which act as suckers.

Prophylaxis.—Prophylaxis against tapeworms consists in eating thoroughly cooked meat and drinking pure water.

Occasionally the **Tænia echinococcus** or the **dog tapeworm** infects man. This is a very small tapeworm, being only $\frac{1}{5}$ to $\frac{1}{3}$ of an inch in length (4 to 9 millimeters). When the ova gain entrance to man's circulation they form a cyst containing a *scolex* which has 30 or 40 hooklets. Depending upon the part of the body attacked will be the effect of the growth of these cysts. Usually the infection is very serious. This parasite is rare in the United States.

Prophylaxis.—Persons having dogs, or caring for dogs, should be very careful to wash the hands before eating and to avoid drinking polluted water.

Cholera

Cholera is an acute gastro-enteritis produced by the *Spirillum asiaticæ choleræ.*

The disease is transmitted by:

1. Carriers;
2. Infected food;
3. Infected water.

Incubation.—The period of incubation seldom is over five days.

Immunity.—One attack confers no lasting immunity. Vaccination appears useless.

Prophylaxis.—Isolate sick and carriers. Sterilize all food and all water and protect both from flies and vermin. Attendants should wear gowns and should disinfect vomitus, dejections, linen, mess gear and everything that may have been soiled by dejections or vomitus. Their hands should be thoroughly disinfected. They should not eat in the sick rooms. Upon recovery or death of the patient the room should be disinfected by using some strong disinfectant solution such as 5 per cent. carbolic acid, chlorinated lime, 1 pound to 4 gallons, 1 to 500 bichloride of mercury or 3 per cent. compound cresol solution. The floor furniture and walls should be washed with this solution.

Fumigation is unnecessary except for the killing of flies or other vermin which may have been infected.

The intimate contact of our men in the war zone with troops from countries where cholera is endemic, causes the disease to assume far more importance than hitherto it has possessed for us.

Yellow Fever

Yellow fever is a disease of unknown cause, found in tropical and sub-tropical countries, and transmitted by an infected mosquito, *Stegomyia calopus*. It is not transmitted by fomites. The disease often concerns the naval medical officer.

The discovery of the mode of transmission was made by Reed, Carroll, Agramonte and Lazear, who constituted a board of U. S. Army medical officers appointed to study yellow fever in 1900–02.

While the cause of yellow fever remains undiscovered the brilliant discovery of the mode of transmission has enabled complete control of the disease.

Stegomyia Calopus.—*Stegomyia calopus* is a blackish-brown mosquito of average size which has bright silvery bands on abdomen, thorax, legs, and palpi. The dorsal surface of the thorax is marked with the lyre-shaped silver marking, which readily identifies the insect. This lyre is composed of two parallel silvery lines lying in an antero-posterior direction, and on each side of these is a curved silvery line which, as it extends backward, finally becomes prolonged parallel to the two parallel lines above mentioned.

The female transmits yellow fever. The male is not a blood sucker. When the female feeds upon an infected person during the first three days of his disease she becomes infected, but the infection requires twelve days in which to develop before she is capable of transmitting her disease to man.

This mosquito lives and breeds about houses wherever conditions are favorable and does not go far from its breeding place. It feeds principally in the day time. This rule is not invariable. I have been bitten by *Stegomyia calopus* at night.

Except as borne by wind *Stegomyia calopus* seldom travels a great distance. Ships at anchor 1000 feet off shore are safe in so far as *Stegoymia calopus* flying to them is concerned. The mosquito may come in bumboats or be driven far by wind from shore.

Period of incubation is two to five days.

Immunity.—No race is immune. One attack of yellow fever confers lasting immunity. Two attacks in the same individual are almost unknown.

Prevention.—The anti-mosquito measures described under malaria (see page 406) will prevent the spread of yellow fever. In the tropics

all persons who develop fever should be placed under mosquito net at once in order to avoid infecting mosquitoes with possible mosquito-borne disease and its consequent transmission to man.

Dengue

Dengue, often met in tropics and sub-tropical countries, is undoubtedly communicated by some flying insect, although its specific cause is unknown. *Culex fatigans* and *Culex pipiens* have been suspected of transmitting it.

Extensive experiments have failed to prove conclusively that either is the carrier.

Craig and Ashburn considered *Culex fatigans* as the transmitter. Recent work in Australia points toward *Stegomyia*. Dengue does not appear contagious. Medical Director R. C. Persons, U. S. Navy, reported that 24 men went on liberty from the U. S. S. Baltimore at Cavite, P. I., and although 20 of these men were taken with dengue, no case of the disease developed among the men who stayed aboard. The writer repeatedly has treated dengue without contracting it.

Period of incubation is two to nine days. The virus is filterable.

Immunity.—An attack of dengue confers no lasting immunity. Repeated attacks occur in the same individual.

Prevention.—The locality of infection should be avoided. The patient should be screened. Until more accurate knowledge concerning the cause and mode of transmission of dengue, prophylactic measures should be directed against the blood-sucking insects, especially mosquitoes.

Plague

Plague is caused by *Bacillus pestis*. The disease appears in three forms:

(*a*) Pneumonic;
(*b*) Bubonic;
(*c*) Septicæmic.

Mode of Transmission.—The pneumonic type is conveyed by sputum, or the droplet method. The bubonic and septicæmic forms are regarded as infectious only through certain fleas and possibly bed bugs. *Xenopsylla cheopis* (the common rat flea of the Orient), and

Ceratophyllus fasciatus (the common rat flea in the United States), transfer this disease of rodents to man.

McCoy studied plague in California where it has been found that ground squirrels, rats, and possibly other vermin carry the disease and transmit it to man through fleas.

Immunity.—One attack confers lasting immunity. Haffkine's prophylactic is said to reduce the probability of infection four-fifths (Martin) and recovery is two and one-half times as frequent among the vaccinated as among the unvaccinated.

Prophylaxis.—Avoid infected localities. Take every precaution against flea bites. Pneumonic plague is very infectious and very fatal. I have seen death occur very rapidly in this type. Physicians

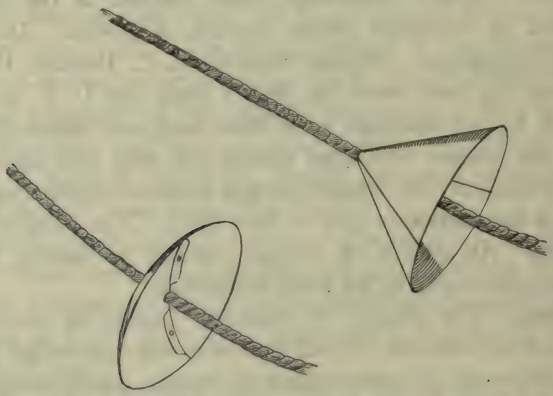


FIG. 141.—Types of rat guards placed upon the mooring lines of a ship to prevent rats coming aboard over the hawsers.

attending plague should wear as a head-covering an inverted closely woven muslin bag which should come down over the neck to the shoulders so it may be tucked inside the collar of the long gown which also should be worn.

The above-described head-gear should have glass goggles in it. Long leggins covering the shoes entirely and extending up to the thighs should be worn. These leggins may well be saturated with kerosene or other flea repellent. Since rodents are reservoirs of the disease and transmit it to man through fleas, every precaution should be taken to keep rats off ships.

Rats may swim a half to three-quarters of a mile, hence in infected

ports they may bring infection aboard by swimming to the anchor chain and coming in through an unprotected hawse-pipe.

When ships are alongside the dock the mooring lines should be tarred or protected with rat guards in the shape of inverted funnels or circular tin guards to prevent rats coming aboard.

The gang-plank should be triced up at night, and during the day a man should be stationed at it to prevent rats reaching the ship by this route.

Ships entering plague-infected ports should be fumigated against vermin once every six months as a routine measure. The period of detention of ships from plague-infected ports is seven days.

Trench Fever

Trench fever or Volhynian fever is a communicable disease, probably due to specific infection, the cause of which is at present unknown.

Etiology.—Observers have reported discovering organisms in the blood or urine of those suffering with trench fever, but neither the microscope nor ultra-microscope has discovered the specific cause. Sergent found semilunar bodies in the blood. Houston and McCloy isolated a coccus from the urine. Pappenheimer found discoid bodies in the blood, and Patterson, Nankivell, and Lundell have found a spirochæte.

Period of Incubation.—Period of incubation varies from six to twenty-two days. This has been determined by experiment.

Mode of Transmission.—Mode of transmission is believed to be through the louse, and there is experimental evidence corroborative of this belief.

Immunity.—Since the specific germ has not been discovered, serum prophylaxis and serum therapy have not given satisfactory results.

Prophylaxis.—Trench fever is a serious condition among troops in the field. For instance, during a year one division of troops sent 350 cases per month to the field hospital. Since the opinion is held and corroborated by experimental evidence that the louse is the principal medium of transmission, prophylactic measures should embrace a constant war upon the louse. Contact with cases of trench fever should be avoided and until there is more accurate knowledge of the cause and mode of transmission careful concurrent disinfection should be practised. Terminal fumigation against lice is recommended.

Acute Infectious Jaundice or Weil's Disease

An acute febrile jaundice having remittent fever and muscular pains with much prostration has been met especially in the trenches. Workers in sewers, ditches and foul water are especially predisposed to this disease. Its specific cause is the *Spirochæte icterohemorrhagica*. This disease is frequently met in Japan and other countries where the population work in rice paddy fields.

It is not clear how the organism gains entrance to the body, whether through the alimentary canal, through open lesions of the skin, or through bites of some blood-sucking form of animal life.

Prophylaxis.—Inada claims that a blood serum of convalescents or serum from an immune horse is of therapeutic value. No immune serum appears of prophylactic value. Consequently prophylaxis consists in endeavoring to avoid infection through the three routes above mentioned.

Relapsing Fever

Relapsing fever is an acute infectious disease due to the spirillum of Obermeier. This organism gains entrance to the blood and after an incubation period of from four to ten days produces the relapsing fever from which it has taken its name.

The disease is transmitted by body lice (Mackie). Bed bugs are said to transmit it (Tiotin). The organism causes febrile periods lasting about six days, which follow one another until the infection dies out.

Prophylaxis.—The prophylactic measures directed against body lice and bed bugs are indicated. Avoidance of exposure and isolation of patients should be practised as in the case of typhus fever. Doctors and nurses should be especially careful to wear insect-proof clothing while about the patient.

Malta Fever

Malta fever is an acute exhausting specific infectious disease caused by *Micrococcus melitensis*. The organism causes the disease in goats and is transmitted to men through the drinking of goat's milk.

Prophylaxis.—This condition may be prevented by boiling the milk of goats if such milk is used for human consumption. The habit of drinking milk freely is very common among the American people and the possibility of this infection should be borne in mind by medical officers who are serving on vessels in Southern Europe.

Typhus Fever

Typhus fever is an acute infectious disease transmitted by the body louse (Nicolle). It is believed to be caused by *B. typhi exanthematici*, a Gram-positive organism discovered by Plotz. Ricketts showed typhus to be identical with the Mexican tabardillo.

Prophylaxis.—Kill body lice and their eggs.

CHAPTER XXXV

DISINFECTION

Disinfection is the process of destruction of disease-producing organisms.

It is either:

(*a*) Concurrent; or
(*b*) Terminal.

(*a*) **Concurrent disinfection** consists in the destruction of pathogenic organisms during the course of the illness wherever these organisms may be, whether in the patient's secretions, excretions, skin, or articles soiled by them—including bath water.

(*b*) **Terminal disinfection** consists in the disinfection, after the illness, of the room, bedding, and articles which may have been infected by the patient during the illness. This frequently includes the use of a gaseous disinfectant and the thorough washing of all surfaces with an antiseptic. Appropriate disinfection of the patient's person should not be forgotten.

Disinfectants may be:

A. Physical;
B. Chemical.

A. **Physical disinfectants are:**

1. Boiling;
2. Steam, under pressure;
3. Streaming steam;
4. Flaming;
5. Dry heat;
6. Burning;
7. Sunlight.

B. **Chemical disinfectants consist of:**

1. Liquids or substances in solutions which act as poisons destroying bacteria;
2. Gaseous agents which act similarly.

A. **Physical Disinfectants.**—1. **Boiling** for a period of one hour will thoroughly disinfect all articles to which the method is applicable. Anthrax and tetanus spores may resist boiling for an hour, but the vegetative forms of these organisms will be killed. Most pathogenic organisms will be killed by boiling thirty minutes. Obviously this method has its limitations in that many articles would be ruined in boiling. For the disinfection of a stool the addition to it of a gallon or more of boiling water putting the top on the chamber and allowing it to cool has proved satisfactory.

2. **Steam under Pressure.**—For disinfection of fabrics, bedding, etc., the application of steam in the autoclave is most effective. Articles exposed to a steam pressure of 15 pounds are under a temperature of about 250°F. Twenty minutes is sufficient to complete sterilization under these conditions.

The autoclave is a double-jacketed metal chamber which may be made air tight. The gaseous content, chamber and jacket of which may be controlled independently by appropriate valves for supplying steam and cutting it off. By another valve the jacket and chamber are made to communicate. Necessary pressure gauge, safety valve, and funnel for pouring water into the jacket are provided. Articles to be disinfected are placed in the chamber which is tightly closed and steam is turned on the chamber until the air is expelled. The air cock is then closed and the pressure is allowed to increase to the desired height; after it is maintained sufficiently long the steam is shut off and in some cases a partial vacuum is established, thus facilitating the penetration of steam throughout the fabrics in the disinfecting chamber.

3. **Streaming Steam.**—Exposure to streaming steam is a satisfactory disinfectant where applicable. It is similar in action and value to boiling.

4. **Flaming.**—For the disinfection of metal articles flaming is very satisfactory and the medical officer on board ship will find that the gasolene torch which is found in the paint shop often will be of service to him in his efforts to prevent spread of communicable disease.

5. **Dry Heat.**—Dry heat at a temperature of 150°C. will kill all forms of life if maintained for one hour. Rosenau states "most materials will bear a temperature of 110°C. without much injury, but when this temperature is exceeded signs of damage soon begin to show. Scorching occurs sooner with woolen materials such as flannels and blankets than with cotton and linen." He suggests using the

oven found in any kitchen when small objects are to be disinfected by dry heat and recommends that the oven be heated "to a point necessary to brown cotton, and expose the objects no less than one hour."

6. **Burning.**—Infected articles which are useless may be destroyed by burning. There is no better method of disposal of sputum, dressings, and the like.

7. **Sunlight.**—Microörganisms exposed to sunlight are killed in a comparatively brief time by dessication and by the direct action of the sun's rays upon the protoplasm of the organism.

B. **Chemical Disinfectants.**—Liquids or substances in solution.

(*a*) Bichloride of mercury;
(*b*) Carbolic acid;
(*c*) Formalin.

(*a*) **Bichloride of mercury** ($HgCl_2$) or "corrosive sublimate" is one of the most common disinfectants in use and kills all forms of animal life in solution in strength of 1 to 1000. For killing spores a solution of 1 to 500 should be used.

Bichloride of mercury is a heavy, white crystalline substance which is highly poisonous to man. Bichloride dissolves slowly in water. The addition to the water of ammonium chloride, table salt ($NaCl$), or hydrochloric acid (HCl), aids in solution.

For disinfection of ships with bichloride of mercury, sea water is useful, since it contains nearly 3 per cent. of sodium chloride and a small amount of ammonium chloride. Geddings recommends weighing the necessary amount of bichloride, placing it in a bag, and attaching to it a faucet, the bichloride being dissolved by the water while it is passing through the bag. The solution of bichloride of mercury always should be tinted with some coloring matter in order to prevent mistaking it for water. It may be applied with a hose for washing down decks and bulkheads of compartments requiring disinfection, or the surfaces may be scrubbed down with rags or brushes.

Rosenau calls attention to the volatility of bichloride of mercury and recommends rinsing surfaces upon which it has been used on a large scale with fresh water in order to avoid bichloride poisoning. Solutions of bichloride of mercury are unsuitable for the destruction of organisms in feces and sputum. They precipitate albumin, thus throwing an envelope around, without penetrating to the center of masses containing living bacilli.

Infected linen may be soaked in solution of bichloride and subsequently rinsed in fresh water. Bichloride does not injure fabrics but corrodes metal, consequently should not be used in disinfecting water closets or plumbing.

Bichloride is not a deodorant.

(*b*) **Carbolic acid** is one of the most popular disinfectants and is especially useful for disinfecting excreta, sputum, and also wood and metal and linen. It is a coal-tar product which is used in solution from 2½ to 5 per cent. Unlike bichloride of mercury solution, it causes local symptoms promptly when it comes in contact with the skin. The spot turns white, tingles, becomes anæsthetic and in some cases gangrenous. Prompt application of alcohol is the best antidote for its local effect. Carbolic acid is a mixture of phenols and cresols and depends upon these for its disinfectant qualities. Phenol has the same disinfecting properties as carbolic acid since it is the principal component of the latter, and its range of applicability corresponds to that of carbolic acid. Various other coal-tar products are sold as disinfectants and their effects are much the same as those of carbolic acid. Creolin, lysol, sanitol, naphthol, aseptol, solveol, asaprol, cresol, naphthalene and other coal-tar derivatives are also used. Carbolic acid and phenol are the best and in solution of 3 to 5 per cent. will kill all non-spore-bearing bacteria in from one-half to an hour.

(*c*) **Formalin.**—Formalin, a 40 per cent. solution of formaldehyde in water, is an excellent disinfectant for sputum, urine, feces or linen soiled by them.

The formalin should be of standard strength and should be used in strength of 10 per cent. of formalin in water.

Gaseous Disinfectants

Two gaseous disinfectants are recommended for use on board ship. These are **formaldehyde** and **sulphur dioxide.** Formaldehyde is the best germicide, sulphur dioxide the best fumigant for the extermination of vermin.

Hydrocyanic acid, carbon monoxide, carbon disulphide, and chlorine all have a limited range of action and **are not** considered **desirable.**

Hydrocyanic acid is extremely poisonous, and being without odor or color has repeatedly resulted in death to those who have unwittingly entered compartments containing the gas in lethal concentration. It

is a valuable fumigant against vermin and less so against bacteria, but is so dangerous that it should not be employed by any who are not thoroughly skilled in using it. Fatal accidents have happened as result of the pocketing of this gas in the holds of ships that had been disinfected by it, the holds having been opened and supposed to be thoroughly aerated and freed from the disinfectant.

Carbon monoxide and the gases of combustion in ships' furnaces have been ingeniously applied to disinfection of holds of cargo-carrying ships. This method has proved satisfactory but requires elaborate and expensive apparatus. This gas being odorless, tasteless, and very toxic can be used only in holds of ships which are unoccupied.

Carbon disulphide is occasionally used against vermin, is highly poisonous, but its disagreeable odor is a safeguard. Its explosive quality renders it unsafe for use.

Chlorine is highly toxic for animal and vegetable life and damages fabrics, colors, and metal to such extent that it should not be employed when other fumigants are available.

Preparation of the Space to be Disinfected.—The disinfection of a room requires careful attention to detail on the part of those doing the work. The room should be as nearly hermetically sealed as possible. The cracks around the doors, transoms, windows, fire-places, entrances of radiator pipes, heating and ventilating openings should be made air-tight by pasting paper over them. For the closure of cracks in the doors, windows and the like, the writer has found the following to be a useful method: Cut strips of newspaper sufficiently wide, say 3 inches, smear green soap over them and then paste over the cracks. This will be found to be air-tight and has the advantage of dissolving readily with water when it is desired to remove the paper after disinfection. Starch paste, flour paste, and the like may be used, but green soap is preferable when available. The key hole, voice tubes, and the crack at the meeting rail of upper and lower window sashes should not be forgotten. Material and utensils should be in readiness to seal the door of exit after the operator has started the generation of the disinfectant, and hurriedly has left the room.

On board ship the fumigation of certain compartments is comparatively easy, and in other cases extremely difficult. The presence of water-tight doors and air-ports, each of which has its rubber gasket, enables the closure of these openings without pasting paper over them. The ventilating louvers must be tightly closed by sealing them up,

and care must be taken to see that the small triangular openings which result from the overlapping of steel plates at their point of contact with a bulkhead are also closed. In state rooms the grating at the top for purposes of ventilation should be closed. Any metal in the room, especially brass, should be coated with vaseline if sulphur dioxide is to be used. Drawers should be opened and their contents shaken out or strung on lines in the room. Bedding should be similarly treated, to enable the gas to come in contact with all surfaces and be disinfected, since the gaseous disinfectants possess little or no penetrating power.

In large compartments on the gun deck there may be great difficulty in closing sufficiently to perform a fumigation. In such case thorough aeration and the use of disinfectant solutions will accomplish the desired effect. If the fumigation of a ship is intended to be general, preparation should be made to commence the generation of the fumigant almost synchronously in the various parts of the ship. It is desirable to commence at one end of the ship, disinfecting one compartment after another and driving rodents and vermin ahead of the disinfecting process toward the other end of the ship. Employment of this method is more apt to result in extermination of vermin than if isolated compartments are fumigated from time to time, the vermin being driven from a compartment, seeking refuge in an adjacent one and returning to infest the fumigated one after the process is repeated.

Formaldehyde.—Formaldehyde is a most useful disinfectant, but is not an insecticide. German cockroaches thrive upon it. It is non-poisonous, does not corrode metal, does not injure fabric or fade colors, and declares its presence by its odor and irritating qualities to the mucous membranes. It polymerizes at low temperatures and disinfection with it is unreliable if the temperature of the space to be disinfected is below 65°F. A certain amount of moisture in the atmosphere is necessary to its successful action, and if the relative humidity is below 60 per cent. moisture should be added to the air of the room. It diffuses with about the same rapidity as atmospheric air. In the generation of this gas for each 1000 cubic feet of space to be disinfected a separate generating apparatus should be employed, and the generators should be distributed throughout the space preferably 4 feet above the floor in order to insure uniform generation of the gas. As considerable heat is generated during the evolution of the gas the containers should not be set upon surfaces which would be injured by heat—for instance carpets and varnished wood.

There are several methods of generating formaldehyde. The following is best:

Barium Dioxide Method.—One-half pound of barium dioxide (technical containing not less than 78 per cent. of BaO_2) crystals should be evenly distributed on the bottom of the bucket or other metal container. Upon this is poured 1 pint of formalin (solution of formaldehyde 40 per cent. U.S.P.). These proportions of the ingredients suffice for the disinfection of 1000 cubic feet of space. The metal container should have pressed seams as the heat generated would melt solder. The formalin should be poured into a pitcher so that it may be quickly poured into the bucket. This precaution is necessary as the gas is immediately and rapidly evolved when the chemicals come together. The method is a cheap, safe, and efficient process for rapid evolution of formaldehyde and possesses the advantage of supplying the necessary moisture.

The container may be readily cleaned since no discoloration is produced as in the permanganate method.

The Health Department of the State of Pennsylvania uses the following method:

Sodium dichromate	10 ounces
Formalin	16 ounces
Commercial sulphuric acid	1½ ounces.

The last two ingredients may be mixed and kept in stock, the mixture being poured upon the sodium dichromate when it is desired to employ this method. The gas is liberated rapidly.

The Potassium Permanganate Method.—This method formerly much used is convenient, wasteful, and dirty. For each 1000 cubic feet of space to be disinfected 500 c.c. of formalin are poured upon 250 grams of potassium permanganate. As in the barium dioxide method there is much spattering, heat is rapidly generated, and the floor or surface upon which the container rests should be protected by placing a brick or something of the kind under it. The process occurs with almost explosive violence and permanganate stain may be spattered some distance about the container. Owing to the present high price of potassium permanganate this method is expensive.

The three methods above described enable the rapid evolution of large quantities of gas.

Walker describes the following useful method for each 1000 cubic feet:

Sol. A—Aluminium sulphate.....	150 grams
Dissolved in hot water.....	300 c.c.
Sol. B—Formalin (40 per cent. CHOH)....	600 c.c.
Lime—Unslaked lime.....	2000 grams.

Mix solutions A and B and pour upon the lime.

Solution A and B are mixed, poured upon the lime, the slaking of which generates heat; the formaldehyde is driven off.

The various lamps and retorts for generation of formaldehyde are unreliable.

Apparatus has been devised by which formaldehyde is admitted into an autoclave in which a vacuum has been produced by steam under pressure. Since the steam under pressure will certainly sterilize and will penetrate, formaldehyde is unnecessary, except for articles which would be injured by steam.

On board ship in small state rooms and in small inclosures such as closets and bureau drawers, the method of sprinkling formalin may be satisfactorily employed.

For the disinfection of small rooms Rosenau recommends the suspension of a bed sheet on a line in the room and sprinkling it with formalin. He states that "a surface of about 2 by 2½ yards is required for every 1000 cubic feet of space of the room. Properly sprinkled this will carry without dripping 8 ounces of formalin."

A room disinfected by formaldehyde should remain closed for twenty-four hours in order to obtain full effect of the gas upon all exposed surfaces.

Sulphur Dioxide.—Sulphur dioxide is par excellence the best fumigant for use against vermin. For its germicidal effect the addition of moisture to the atmosphere is required, the moisture in the air plus the sulphur dioxide results in the formation of sulphurous acid which is germicidal.

In concentration sulphur dioxide produces corrosive effect upon exposed metal and attacks fabrics. The action upon fabric is not immediate but manifests itself slowly, perhaps after laundering. For germicidal action a concentration of 5 per cent. of the gas should be employed—3 per cent. is sufficient for use against vermin. Of the several methods of application the most practical is the burning of pulverized roll sulphur or of flowers of sulphur.

For **germicidal** effect 5 pounds of sulphur should be burned per

1000 cubic feet of space to be disinfected, and moisture should be added to the air in proportion of 1 pint per 1000 cubic feet.

For Vermin.—Two to four pounds of sulphur per 1000 cubic feet should be burned for fumigation against vermin. For this purpose the addition of water is unnecessary and its omission results in less damage to fabric or metal.

The following important points should be observed in sulphur fumigation:

1. The room should be tightly sealed;

2. The sulphur should be placed in a shallow iron pot or vessel of solid casting;

3. This vessel should be set in a somewhat larger one partially filled with water if germicidal action is desired.

When the sulphur burns sufficient amount of water is vaporized to make the sulphur dioxide effective against microörganisms. The water also is a safeguard against fire. The writer has found that the ignition of sulphur is difficult even with the addition of a small amount of alcohol, and has found the following the most satisfactory way of preparing the pot for ignition. The necessary amount of sulphur for each pot is weighed. The interior of the pot is thoroughly dried. A newspaper is lightly crumpled and put in the bottom of the pot. The powdered sulphur is then poured over the newspaper. To this is added sufficient alcohol and the pot is ready for ignition. Vessels with soldered seams or which have been patched by soldering should not be used as sulphur pots, for the heat generated melts the solder and the water in which the pot is resting flows in and extinguishes the flame. If apparatus is available not in excess of 10 pounds of sulphur per pot should be used. It is much better to use a larger number of pots as the gas is better distributed throughout the compartments and the complete combustion is more nearly probable.

Sulphur dioxide is heavier than air, sinks to the bottom of the compartment and tends to extinguish the burning pots by cutting off their oxygen supply. Consequently the pots should be placed as far above the floor as it is practicable, upon boxes of scaffolding temporarily erected for the purpose. When all is ready the pots farthest from the exit should be ignited, and the others ignited as the operator goes toward the door. Having satisfied himself all are burning the door should be closed and sealed. If disinfecting against microörganisms the room should be kept sealed for twenty-four hours. Three hours is sufficient

when fumigating against vermin, but the space should be left closed for twelve hours if practicable.

Quarantine

Medical officers of ships acting as health officers of the population under their charge are required to comply with the quarantine laws of this and other countries, and also naval medical officers from time to time are required to act as health officers of the port in certain of our colonial possessions.

Ships arriving in the United States with any one of the following diseases on board are quarantinable; namely: leprosy, cholera, plague, smallpox, yellow fever and typhus fever.

Alien lepers are not permitted to land. Lepers, if citizens of the United States, must be handled in accordance with the local laws in force at the port of landing.

Persons exposed to cholera should be quarantined for the full period of incubation; namely, five days; yellow fever, six days; smallpox, eighteen days; typhus fever, twelve days; plague, seven days.

The certificate of a naval medical officer concerning the sanitary conditions prevalent on his ship is usually accepted by the health authorities of the port.

When the naval medical officer is acting as health officer of a port he should upon boarding an incoming vessel make a quick survey of general appearance of passengers on deck. He should then call for the medical officer of the ship. If a naval vessel the certificate of the medical officer should be accepted, provided his bill of health is satisfactory. If a merchant vessel is boarded the ship's physician should be required to show his bill of health, interrogated as to development of any infectious disease during passage, journal and clinical records should be read, and sick should be examined. If any have died at sea the bodies should be viewed and autopsied if necessary. Then a general muster of all hands should take place, and a careful count of passengers and crew should be made and the result compared with the number of souls on board ship as given in the bill of health. Any discrepancy found should be brought to the attention of the commanding officer for explanation. The general muster should include a careful examination of all hands, for unscrupulous captains have compelled men sick with quarantinable disease to stand in line to try to pass quarantine

muster. After the muster a general view of the vessel should be taken and cargo containing food stuffs, grain, cereals, and flour should be examined carefully as they are apt to harbor vermin. The attitude of the captain of the vessel and of the ship's surgeon should be carefully considered in all cases. Treatment of those sick of quarantinable disease and management of quarantine station cannot be discussed here.

CHAPTER XXXVI

DISPOSAL OF THE DEAD

For sentimental reasons so well-grounded in the popular mind that they cannot be ignored, and because of effect on morale of the sailor-man, effort is made to return to their homes the bodies of those in the naval service who die at sea or abroad. If the death results from an infectious disease the body must be interred abroad for the period of one year before it may be returned to the United States.

The bodies of those who die on board ship should be embalmed for preservation and shipment.

Embalming.—Complete saturation of the body tissues with the embalming fluid must be accomplished.

Both brachial, both femoral and both common carotid arteries should be injected. The arteries of the extremities should be injected peripherally.

One carotid should be injected toward the head and the other toward the heart.

Francis says an amount of fluid equal in weight to 15 per cent. of body weight should be injected if the body is to be kept long in warm temperatures. Of this each brachial should receive 1 per cent. of the body weight; each femoral 2 per cent.; the common carotid injected toward the head 2 per cent., and that toward the heart 2 per cent.

Body cavities should be injected, and if autopsied special care must be taken to see that the vessels are well filled and tied.

A bicycle pump and a 3-gallon bottle having a rubber stopper perforated by two glass tubes, one of which extends to the bottom of the bottle, and is connected with the rubber tube which terminates in the injecting needle, the other tube which pierces the stopper is connected with the bicycle pump and extends into the bottle only sufficiently far to discharge air above the level of the fluid, constitute the injecting apparatus.

The ordinary fountain syringe or irrigating bottle equipped with a cannula or needle may be used. The aspirator which is supplied in

the medical department when appropriately connected is an excellent instrument for injection and also for aspiration of blood if necessary.

The following solution has been found most satisfactory by the Hygienic Laboratory of the U. S. Public Health Service:

Liquor formaldehyde	
(U.S.P. solution of formaldehyde).....	13.5 c.c.
Sodium borate ($Na_2B_4O_7$, borax).....	5 grams.
Water sufficient to make.....	100 c.c.

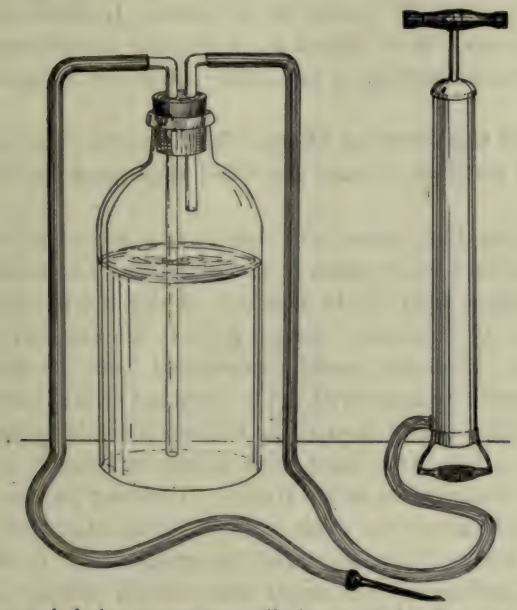


FIG. 142.—An embalming apparatus easily improvised. It consists of a bicycle pump, a jar, a cannula, and some tubing.

It is stable.

Bodies injected with this fluid have been well preserved after exposure to a temperature of 98°F. for two months.

Massage will remove postmortem staining of the face. Before they can be moved bodies dead of infectious disease must be washed in an approved disinfectant fluid after embalming.

All body orifices should be plugged with absorbent cotton saturated with the fluid. The body should be covered with a cotton layer 1 inch thick and wrapped in a sheet wet with disinfectant.

For shipment of over twenty-four hours the body must be prepared as above described and encased in a hermetically sealed (soldered) tin case inside the coffin.

Burial at Sea.—When it is impracticable to return a body to its home it may be necessary to bury it at sea, in which case it is sewed in tarpaulin, weighted, and slid overboard with appropriate ceremony.

In Action.—During or after an action in which many persons are killed it may be necessary to throw the dead overboard as rapidly as possible for the two-fold purpose of clearing the ship of the bodies and for effect upon the morale of the crew. In such circumstances the conditions may be so urgent as to warrant committing the bodies to the sea without sewing in tarpaulin—time and material not being available.

Disposal of the Dead on Shore.—When naval forces are operating on shore and numbers of men are killed they must be buried on the field.

The site should be chosen with view to minimize effort during transportation, due care being taken to avoid proximity to dwellings, water supplies, or places likely to be flooded. A dry sandy soil with gentle slope is best if available. Large graves, holding say 100 bodies, may be used. Clothing should be removed from the bodies and no antiseptics should be employed. The trenches should contain a single row of bodies and should have at the bottom of the large trench a small trench about a foot deep lined with stones or boughs, or some such materials, for draining the larger trench. In filling the trench it should be remembered that access of air and circulation of ground water favor bacterial growth and produce rapid decomposition. A vent made of three boards perforated with auger holes should extend to the bottom of the trench in order to enable the escape of gases of decomposition.

The corpses should be covered with boughs, useless articles of clothing, then the turf, and the grave filled in with earth. Appropriate markers should be placed if the bodies can be identified.

When for any reason putrefying bodies are exposed, if they cannot be buried immediately they should be treated with a 5 per cent. cresol solution, quicklime, or a 10 per cent. solution of ferric sulphate.

The writer has seeen bodies incinerated after battle by placing them in layers between which were interposed fire wood. The wood and the bodies were drenched with kerosene and the pyre ignited. This method is commended where practicable since it prevents fouling and infection

of ground water. The ashes can be buried and appropriate markers may be established.

It is alleged that the German Government has disposed of some of the dead by rendering the bodies, obtaining a lubricating oil from the fats and a compressed material which is used as food for hogs.

CHAPTER XXXVII

VITAL STATISTICS

Vital statistics are mathematical expressions of the extent and movement of morbidity and mortality in a given population. By means of these expressions studies in prophylaxis and comparisons of results of effort to conserve health may be made.

Values of methods of treatment may be tested and the results expressed in terms capable of comparison. Disease and injury in sex, age, and occupational groups gain expression in terms of comparison comprehensible by the layman who must appropriate funds for the carrying forward of public health work and must legislate for the maintenance of the health of the people.

Manifestly the value of vital statistics depends upon accuracy of diagnosis and scrupulous care in the keeping of the records. The statistics which are being compiled by the military arms of the federal service are probably as accurate, if not the most accurate of any, for the same population, and medical officers cannot be too careful in endeavoring to eliminate error of any kind from their reports.

The naval medical officer should understand the meaning of several terms commonly used in connection with the vital statistics of the Navy. These are:

1. The average strength;
2. The sick day;
3. The daily average of sick;
4. The percentage of sick;
5. The ratio per thousand of admission, invaliding and death.

1. The Average Strength.—By the average strength is meant the daily average population during the period of time under consideration. If the daily average number of persons on board a ship during a week, month, or year is 1125, this number is the average strength of the ship. It includes officers and enlisted men, sick and well.

Probably it may be most accurately determined by appropriate

calculations based upon the amount of money paid by a given unit to the naval hospital fund during a given time. The law requires that each person in the naval service contribute 20 cents a month from his pay to the naval hospital fund. If during three months the total checkages for the hospital fund aggregate $720, this amount will represent 20 cents a month checked three times (months) for each individual on board, consequently $720 divided by 60 cents will give 1200, the average strength of the crew during the three months.

A common method of obtaining the average strength is to divide the number of rations issued during the period of time by the number of days in that period. One ration per day is allowed to each enlisted man. Hence the number of rations issued during a given period divided by the number of days in that period will give the average strength. This appears the simpler, but since rations are not allowed to the officers it is obvious that a considerable factor of error occurs in this method.

2. The Sick Day.—The "sick day" means one man sick one day.

3. The Daily Average of Sick.—The daily average of sick is obtained by dividing the total number of sick days for a given period by the number of days in that period. For instance, if the number of sick days for the third quarter of the year amounts to 644 on board the U. S. S. North Dakota and the total number of days in that quarter is 92, then the daily average number of sick is obtained by dividing 644 by 92 equals 7, or an average of 7 persons sick each day during the quarter. The daily average of sick for the year may be obtained on the same principle.

4. Percentage of Sick.—The percentage of sick may be determined by multiplying the number of sick days during a given period by 100 and dividing the product by the average strength multiplied by the number of days in the period. For instance, if on the U. S. S. Arkansas during the first quarter, 1915 there were 270 sick days because of fractures, what was the percentage of sick for this injury if the average strength of the crew was 1200?

$$\frac{270 \text{ (sick days)} \times 100}{1200 \text{ (average strength)} \times 90 \text{ (no. of days in first quarter of 1915)}} =$$

$\frac{270 \times 100}{1200 \times 90} = 0.25$ or $\frac{1}{4}$ per cent. = the percentage of the crew on the sick list each day during the quarter because of fractures. This means $1200 \times 0.0025 = 3$ men.

5. The Rates per 1000 of Admissions, Invalidings and Deaths.—The rate of admissions, invalidings, and deaths may be expressed in rate per 1000 of average strength. This may be obtained by multiplying the total number of admissions, invalidings or deaths by 1000 and dividing by the average strength.

For instance, there were 287 admissions to the sick list in the Navy for tuberculosis during the year 1916. What was the rate per 1000 if the average complement of the Navy was 69,294?

$$\frac{287 \text{ (total number of admissions)} \times 1000}{69{,}294 \text{ (average strength)}} = 4.14 \text{ per } 1000.$$

Since there are $69\ ^{294}/_{1000}$ thousands in the average complement the ratio per 1000 also may be determined by dividing the total number of sick days by the number of thousands.

$$287 \div 69\ ^{294}/_{1000} = 4.14.$$

The average strength or complement may be expressed in thousands by pointing off three decimal places, *e.g.*, $69{,}294 = 69\ ^{294}/_{1000}$ or 69.294 thousands.

Consequently the rate per 1000 for admission, invaliding from service, or for death may be found by dividing the total number of sick days by the average strength in which three decimal places have been pointed off. Taking the above example $287 \div 69.294 = 4.14$ per 1000.

CHAPTER XXXVIII

GLOSSARY OF NAUTICAL TERMS USED

A

Abeam—opposite the center of the ship's side.

Accomodation ladder—a ladder shipped at the gangway for boarding a vessel in port.

After-part—third division or rear portion of a ship; that portion farthest from the bow.

B

Beams—horizontal bars of metal connecting corresponding starboard and port frames, and supporting the decks.

Belay—to secure, make fast, or stop.

Bilge—the flat part of the ship's body on each side of the keel.

Bilge keel—large pieces of metal secured near the turn of the bilge to lessen the ship's motion while rolling.

Bill board—a ledge on the bow of a ship to support the anchor fluke.

Bitts—vertical posts of metal or timber securely fastened in the deck; hawsers are secured to them.

Boatswain—a warrant officer who has care of the ground tackle, stores and apparatus on deck.

Bollard—a vertical pile to which ship's hawsers may be secured.

Boom—a long spar extending from the ship's side and affording place for securing small boats; also used in hoisting cargo aboard.

Bow—the forward end of the ship.

Boxing the compass—naming the points of the compass in order.

Bridge—an elevated platform usually extending entirely across the ship from which the ship is controlled while under way.

Brig—the ship's prison.

Brow—a gangway from ship to a nearby dock.

Bulkheads—vertical walls subdividing the ship's interior.

By the head—when the draft of a vessel is greater forward than aft.

By the stern—when a vessel has greater draft aft than forward.

C

Cabin—the quarters of the captain or admiral on board a man-o'-war. This term is applied to a stateroom on a passenger steamer.

Camel—a float to prevent a vessel from striking the dock when mooring.

Capstan—a drum of metal rotating vertically or horizontally on a central spindle; when forced to run it may lift heavy weights, for instance the anchor.

Catch a crab—to catch an oar in the water the wrong way when rowing.

Clothes stop—a piece of white line tied around a rolled garment to retain the roll. Also used to tie garments on a clothes line.

Coaming—the raised boundary of the hatchway which prevents water entering.

Cofferdam—water-tight cells filled with cellulose. These usually are placed along the water-line in unarmored positions. If a shell strikes and water enters, the corn pith swells and stops the leak.

Conning tower—a structure of armor 12 or 15 inches thick to protect the commanding officer and prevent destruction of communications and steering in battle.

Counter—that portion of the stern extending from the water-line to the overhang.

Cutwater—the forward edge of the stem which cuts the water when the ship is in motion.

D

Davit—a boom or out-rigger which projects from the side of a ship. used for hoisting boats or heavy weights.

Dead light—a piece of heavy glass fixed in the deck or side to admit light.

Displacement—the actual weight in tons displaced by a ship.

Ditty box—a box used for keeping toilet articles, writing materials, etc.

Dog watch—a watch two hours long; usually a watch lasts four hours and the four-hour period from 4 to 8 is divided into two dog watches in order that the watch standers will rotate in their watches.

Double bottom—the space between the inner and outer bottom.

Dungarees—working clothes made of heavy blue cotton cloth.

E

Eyes of the ship—the extreme forward portion of a ship.

F

Fall—a line run through a block for hoisting boats or weights.

Field day—general cleaning day, usually Saturday.

Forecastle—that portion of the main deck between the foremast and stem.

Forward—the first of the three dimensions of a ship, the second being midships, and the third the after-part.

Frames—the ribs rising from the keel to form the body of the ship. Plating is attached to them.

G

Galley—the range and kitchen aboard ship.

Go about—change the tack of a sailing vessel.

Ground tackle—gear used to moor or anchor a ship.

H

Halliards—the lines which hoist or lower the top mast or jib.

Hammock nettings—spaces along the inner side of the ship used for stowing the hammocks of the crew.

Hatchway—an opening in the deck forming a passageway from one deck to another.

Haul—to pull on.

Hawse holes—holes in the bow for the ship's cables to pass through.

Hawse plug—plugs fitted in the hawse holes to prevent water coming on board through them; when made of canvas or stuffed with oakum are called "Jack asses."

Heave to—to deaden a vessel's headway.

Holds—spaces in the forward part of the ship in which the gear of the ship is stowed.

I

Irish pennants—loose ends or rope yarns depending from the rigging or deck.

J

Jacob's ladder—a rope ladder swinging from a boom.

K

Keel—first piece of metal or timber laid in building the ship.

L

Louver—an opening for ventilation.

Lucky bag—a place in which articles or non-regulation clothing are put after confiscation if found in unauthorized places. Articles in the lucky bag which are not claimed are sold at auction from time to time.

M

Magazine—space in which powder is stowed.

Manger—part of the main deck partitioned off to prevent water coming through the hawse holes from running aft over the decks.

Mess gear—eating utensils.

Midships—the middle part of the ship. Lies between forward and after parts.

P

Painter—the line leading from the bow of a small boat by which it may be made fast.

Pipe down—a boatswain's call, meaning that the day's work is finished.

Port—left hand side of a ship looking forward.

Ports—openings in the ship's side for various purposes.

R

Rudder—the apparatus used to steer a vessel.

S

Screw—the propeller.

Scuppers—holes in the waterways through which water is conveyed overboard through pipes.

Scuttle—round or square holes in the deck for passage of coal or stores.

Sea ladder—steps made fast on the ship's side. Used for coming on board when the accommodation ladder is not available.

Sheet—a line which is used to set a sail and hold it in position.

Shrouds—lines from the mast head to the rail.

Sick bay—the ship's hospital.

Smoking lamp—a time of leisure when men may rest or smoke.

Spit kid—a cuspidor.

Squilgee—a piece of rubber in a wooden clamp used for drying the deck.

Stanchions—vertical pillars of wood or metal supporting some other portion of the ship.

Starboard—the right-hand side of the ship facing forward.

Steerage—the quarters of the junior officers.

Steerage way—the lowest rate of speed at which a ship will steer.

Stem—vertical extension of the keel to which the plates are attached.

Stern—the after-end of the ship.

Stern-post—the vertical extension of the keel to which the stern plating is attached.

Stop—to secure by tying with a small cord.

Storerooms—spaces used for stowing various stores.

Stretchers—movable pieces extending across the bottom of the boat against which the oarsmen may brace their feet in pulling.

T

Taffrail—a rail around a vessel's stern.

Thwarts—seats on which the oarsmen sit.

Tiller—a piece of timber or metal fitted fore and aft to the rudder to control it.

Trimming tanks—lower compartments in extreme ends of a ship, and provided with sea valves for filling and pump suction for emptying.

Truck—small wooden cap covering the mast head or the top of a flagstaff.

Turn-to—the signal for work to begin.

U

Unship—to remove anything from where it has been made fast.

W

Wardroom—the quarters of officers junior to the captain, but senior to the junior officers.

Water-line—the line the water makes on the ship's side when she is afloat.

Water-tight compartment—one of the ship's subdivisions which may be made water-tight.

Waterways—gutters extending all around the edge of the upper deck.

Wig-wag—a system of signalling with a flag.

Wings—the portions of the hold nearest the sides of the ship.

APPENDIX

PHYSICAL EXAMINATION OF RECRUITS

FOR ENLISTMENT IN THE

NAVY AND MARINE CORPS

The following instructions for physical examination of recruits for the U. S. Navy and Marine Corps are taken from a circular prepared by Surgeon H. L. Dollard, U. S. N., for the use of student officers at the U. S. Naval Medical School.

They are based upon U. S. Navy Regulations, Instructions, and Manual for the Medical Department.

The heavy faced numerals indicate an article of corresponding number in the Manual.

Physical Examination of Recruits for Enlistment in the Navy and Marine Corps

2051. Whenever any person is examined physically for the Navy or Marine Corps, whether subsequently enlisted or rejected, his name and the particulars shall at once be entered on Form X (rough). This form shall be prepared for each applicant examined, whether accepted or rejected, for original or reënlistment, and will be kept for the purpose of preparing Form X. It shall be retained for ship or station files and shall be filed alphabetically, by calendar years, according to the applicant's surname, in order that information may be furnished the bureau upon request.

Be careful to strike through with ink the term not applicable to the case.

Form X shall be prepared from the Form X (rough) kept for the purpose, and will be forwarded from receiving ships, Navy and Marine Corps recruiting stations, and marine recruit depots for the quarters ending March 31, June 30, September 30, and December 31; from other ships and naval stations or yards for the year ending December 31, or when a ship is placed out of commission or a recruiting or other station closed.

A copy shall be retained for ship or station files. If there have been "No applicants," the report shall be forwarded and this fact so stated in the blank spaces opposite "Navy" and "Marine Corps."

Central recruiting stations shall include in their report the substations and traveling parties coming under their jurisdiction.

Medical officers of ships, naval stations, or yards making examinations for ships or stations to which no medical officer is assigned shall include these items in their reports.

Civilian examiners at substations of the Marine Corps will prepare and forward Form X (rough) to the central stations.

2052. In case a waiver is requested, the action will be noted on Form X (rough) after the cause of rejection, and approval of waiver shall be entered on this form, and also in the service and health records. (R 3523 (3); I 3209.)

2053. Marine recruit depots shall distinguish between "Accepted applicants" transferred from recruiting stations to the depot and those applying originally at the depot by making the proper entry in the space provided on this form.

2054. Previous Army service shall *not* be considered a reënlistment. Previous Navy or Marine Corps service shall be considered a reënlistment in the Navy, and previous Marine Corps or Naval service shall be considered a reënlistment in the Marine Corps, so far as it applies for use in the preparation of this form.

2055. The term of enlistment of all enlisted men of the Navy shall be four years, except minors over seventeen and under eighteen years of age, who shall be enlisted for the period of minority. Minors under seventeen cannot enlist in the Navy. No enlistment for special service is allowed.

2056. No minor under the age of eighteen years will be enlisted without the written consent of the parent who is his legal guardian; or, if both parents are dead, of a legally appointed guardian.

Minors under but claiming to be over eighteen years of age are liable, if enlisted, to punishment for fraudulent enlistment under the act of Congress approved March 3, 1893.

2057. Only such persons shall be enlisted as can reasonably be expected to remain in the service, and when enlisted must serve out the term of their enlistment, and cannot be discharged prior to that time, except for cause or as otherwise provided.

2058. Every person before being enlisted must pass the physical examination prescribed in the medical instructions, and no person shall be enlisted for the naval service unless pronounced fit by the commanding and medical officers.

2059. No person other than a medical officer shall be permitted to conduct any part of a physical examination, to make any measurement, or to make any original entry on any medical record of enlistment.

2060. Every such examination must be completed according to the official forms, and shall in no case be suspended on the recognition of a disqualifying defect.

2061. Medical officers on recruiting duty shall exercise great care and thoroughness in conducting the physical examination of persons presenting themselves for enlistment. While these instructions are applicable in general to all physical examinations, they are intended to cover more particularly the examinations of applicants presenting themselves for original enlistment. While permitted to use his own discretion as to the routine of procedure, the medical officer shall make inquiry on all points indicated below: After testing the vision, color perception, and hearing, and estimating the general fitness of the applicant, his height, weight, and chest measurements may be taken and recorded, the clothing having been removed. A general inspection and regional examination is then made, as follows:

(*a*) The applicant, entirely nude, is to stand before the examiner, in a bright light, and present successively front, rear, and sides (Retarded development, deformity or asymmetry of body or limbs, knock-knees, bow-legs, or flat feet,

especially in minors; spinal curvatures; feebleness of constitution; strumous or other cachexia; emaciation, obesity; cutaneous or other external disease; glanduar swellings or other tumors; nodes; varicosities, cicatrices; indications of medical treatment, leech bites, blister stains, seton or scarification scars; and evidences of smallpox or successful vaccination, or the administration of salvarsan.

(*b*) Applicant to present dorsal and palmar surfaces of both hands; to flex and extend every finger; to grasp with thumb and forefinger and with whole hand; to flex and extend, pronate and supinate wrists and forearms; to perform all the motions of shoulder joints, especially circumduction; to extend arms at right angles to body, and then bend elbow and touch the shoulders with the fingers; to elevate extended arms above the head, palm to palm, then dorsum to dorsum; to evert and invert the feet; to stand on tiptoe, coming down upon the heels quickly, and then lifting toes from floor; to flex each thigh alternately upon the abdomen, and, while standing on one leg, to hop; to perform all the motions of the hip joint; and to walk backward and forward slowly and at double-quick.

(*c*) Note effect of these violent exercises on the heart and lungs; observe movements of chest during prolonged inspiration and expiration; examine by percussion and auscultation front and rear. (Incipient tuberculosis, valvular disease.) Care should be taken to differentiate between organic murmurs and the functional varieties.

(*d*) With hands on the head and chin up, applicant to cough violently (relaxation of umbilical and inguinal regions; hernia; concealed venereal disease, especially beneath prepuce and within urethra; varicocele; orchitis and other abnormal conditions of testes).

(*e*) Applicant to bend body forward, with knees stiffened, feet wide apart, hands touching the floor, and nates exposed to strong light (hemorrhoids, prolapsus, fistulæ). While the applicant is stooping make firm pressure on the spinous process of each vertebra (noting spinal tenderness).

(*f*) Motions of head, neck, and lower jaw.

(*g*) Cranium and scalp (malformations, depressions, cicatrices, tinea, vermin, etc.).

(*h*) Ears (polypi; otorrhea, perforation, dullness of hearing, and degeneration stigmata).

(*i*) Mastoid region for scars or tenderness.

(*j*) Eyes (absence of ciliæ, tarsal redness, obstructed puncta, corneal opacities, adhesions of iris, defective vision, abnormal conditions of conjunctivæ, trachoma, pterygium).

(*k*) Nose (polypi; ozena; chronic nasal catarrh).

(*l*) Mouth, teeth, tongue, fauces (hypertrophied tonsils; syphilitic affections, impediments of speech, lingual scars, cleft palate, and repulsive stigmata or scars of the face, grotesque tattooing, or the expression characteristic of adenoids).

2062. No educational standard has been officially established for recruits presenting themselves for enlistment in the naval service. The regulations require, however, that a candidate shall be able to read and write and that he should possess a reasonably quick and clear understanding. His general intelligence may be estimated by his manner of answering the questions addressed to him in obtaining the data required in the health record, and any impediments of speech noted.

2063. Section 1420 of the Revised Statutes forbids the enlistment in the naval service of any intoxicated person. The evident intention of the law was not only to prevent the admission into the service of men who at the time of presenting themselves for enlistment were under the influence of alcoholic stimulants or drugs, but of those also who were of intemperate habits. A thorough inquiry should be made into the history of any applicant in which habits of intemperance are suspected. Long indulgence in habits of intemperance will be indicated by persistent redness of the eyes, tremulousness of the hands, sluggishness of the intellect, satin-like texture of the skin of the body, an eruption upon the face, and purple blotches upon the legs. The morphine habitué is often emaciated, prematurely senile, with foul breath, contracted pupils, peculiar pallor, dry skin, and often showing multiple punctures of the skin from the needle. The habitual user of cocaine may be suspected when the applicant exhibits unusual buoyancy and mental overactivity accompanied by irrelevant volubility. Cocaine "snuffers" will usually show a characteristic hyperemia of the nasal mucous membrane. Medical officers should endeavor to eliminate the insane, vagrant, and criminal classes by a careful study of the personal characteristics of each applicant. Any doubt as to the mental stability of the applicant should determine a careful investigation directed toward his previous history.

2064. Certain defects which are frequently found associated with the physical condition in cases of reënlistment or continuous service are not necessarily causes of rejection. If deemed of sufficient importance to cause rejection, a waiver of the defects may be recommended, provided that such disabilities will not interfere with the performance of duty. Waiver is requested on "Report of Rejection," procurable from Bureau of Navigation (Form No. 54). This report shall be forwarded in all cases of physical rejection of continuous-service men. (R. 3528.) Physical infirmities incident to advanced years and long service should be carefully considered in these examinations and especially in the case of reënlistment under continuous service. Slight physical defects in those applicants who have matured are of less importance than when occurring in minors.

Physical disqualifications of a minor nature of probably temporary duration readily amenable to medical or surgical treatment should not necessarily cause rejection, if the candidate is otherwise qualified and desirable. Application will be made to the bureau for the admission to hospital of such cases as supernumeraries for treatment of such duration as may be desirable, having in view the removal of disqualifying defects and the ultimate enlistment of a candidate who is in all other respects qualified. In stating the cause of rejection in such cases ambiguous terms should be avoided and the degree of visual and auditory defects should be given. (M. and S. No. 123734.)

2065. The examining surgeon shall consider carefully the physical adaptability of the applicant in relation to the character of the duties which he may be called upon to perform. Moderate height and compact build are requisite in the ratings of fireman and coal passer. The duties pertaining to these ratings are extremely arduous, and applicants for such positions and candidates for transfer to these ratings must conform in every particular to the required physical standard. As a general rule minors should not be recommended for the ratings of fireman and coal passer.

2066. Slight physical defects in applicants who belong to the sea-faring class, or in those who have had experience in military life, have less significance than they might otherwise have in the cases of recruits whose lives have been passed in occupations of a more confining and debilitating character. In the latter class of candidates the unusual and peculiar services that would necessarily be exacted of them might develop any weakness or constitutional physical traits that existed prior to enlistment.

2067. While it is not expected that candidates for special ratings should possess the physique and endurance of those actively engaged in strictly military duties, the examining surgeon should remember that all candidates examined for the several special ratings are enlisted for the performance of all duties pertaining to the naval service ashore and afloat.

2068. The examining surgeon should consider carefully the physiognomy of the candidate. Where the applicant's face is marked by great deformity, warts, or extensive birthmarks, he shall be considered undesirable for the service and shall be rejected.

2069. The examining surgeon shall exercise the greatest care in the examination of the candidate's feet. Pronounced flat foot, loss or deformity of the large toe, or of two of the smaller toes on one or both feet, partial ankylosis of the ankles, marked callosities or ingrowing toenails, and any other defects which in the opinion of the examining surgeon may interfere with marching or prolonged sentry or deck duty shall be considered causes for rejection of the applicant.

2070. The absence of or the marked deformity of the right index-finger or thumb shall cause the rejection of the applicant. The importance attached to the absence of or deformity of the left index-finger or thumb will depend upon the adaptability of the applicant for his special rating, and provided that he is otherwise physically sound.

2071. In determining the weight to be attached to slight degrees of varicocele, varicose veins, and hemorrhoids, the examining surgeon shall carefully consider the age, the general physique, and the rating of the applicant. All candidates with hydrocele shall be rejected, also all candidates with varicocele when accompanied by atrophy of the testes, pain, or an evident neurotic state.

2072. Marked enlargement in either testicle or the absence of both testicles shall cause the rejection of the applicant. Applicants whose clothing exhales the odor of urine, or who present any evidences of incontinence of urine, shall be rejected. Cases of epispadias and hypospadias shall be rejected.

2073. Every recruit must have at least 20 sound teeth, and of these not less than 4 opposed incisors and 4 opposed molars; but, if otherwise qualified and desirable, a waiver may be requested in the case of a candidate not having 4 opposed incisors and 4 opposed molars.

2074. The examination for visual acuteness is of the utmost importance and shall be conducted by the medical officer with the greatest care and patience. An appreciable percentage of men are the subjects of slight visual defects, and in the cases of many of those presenting themselves for reënlistment and enlistment these defects may not be sufficiently serious to disqualify them for the naval service. The ignorance, fear, or stupidity on the part of an applicant undergoing examination

should be taken into consideration by the examining surgeon, and unless the examination is conducted with care and deliberation an applicant may be rejected whose vision is really good. Slight errors on the part of the applicant, such as misreading a P or T for an F, provided the majority of the letters or test characters are read with facility, need not be sufficient cause for rejection. The examination shall be conducted in a large well-lighted apartment, and the test cards shall be placed in a good light. The applicant stands at a distance of 20 feet, one eye being tested at a time, and the other covered by a card. Vision is to be expressed as a fraction, of which the numerator shall be the distance at which Snellen's 20-foot test can be determined and the denominator 20. Normal vision (20/20) for each eye, tested separately, shall be required, but in candidates who are otherwise physically sound a minimum visual acuteness of 15/20 shall suffice. The existence of several minor defects, combined with a visual acuteness of 15/20 in each eye, shall cause the rejection of the applicant.

2075. Color perception is to be carefully determined. The usual examination is by Holmgren's method, which may be briefly described as follows: The worsteds are placed in a pile in the center of a white surface in good daylight. The green test skein is placed aside upon the white cloth, and the person to be examined is directed to select the various shades of the same color from the pile and place them by the sides of the sample. The color blind will make mistakes in the selection of the shades; or a hesitating manner with a disposition to take the wrong shades may show a feeble chromatic sense. The purple test skein is then used. If the test with the green skein has shown the person examined to be color blind, and on the second or purple test he selects only the purple skeins, he is incompletely color blind; but if he places with the purple shades of green or gray, he is completely green blind. The red test skein need not necessarily be used, but it may be employed to confirm the diagnosis already made; for the red blind will select, to match the red skein, shades of green or brown which to the normal sense seem darker than the red, while the green blind will select the shades of green or brown which seem lighter.

2076. The organs of hearing, both the conducting apparatus (outer and middle ear) and the percipient apparatus (internal ear) must be free from disease. In testing the hearing of the applicant advantage should be taken of the absence of other sounds to make the examination. Medical officers should remember that the applicant may be totally deaf in one ear and yet may hear all ordinary conversation perfectly if the sound ear is not completely closed. Deafness may be caused by an accumulation of hardened wax, therefore an otherwise desirable recruit should have his ears well cleaned before final action is taken in his case. Hearing shall be expressed as a fraction, of which the numerator shall be the distance in inches at which the ticking of an ordinary watch can be heard, and the denominator 40. If the voice is used, hearing shall be expressed as a fraction, of which the numerator shall be the distance in feet at which the voice of the examiner can be heard and the denominator 15. The voice is a more reliable method of determining the acuteness of hearing than the watch test, as it allows for variations in hearing with the modifications produced by changes in pitch and tone. Complete deafness in either ear shall be considered a sufficient cause for rejection. Before completing the examination the medical officer shall satisfy himself of the patency of the eustachian tubes and the integrity of the tympanic membranes.

2078. In every case of rejection, the disability unfitting the applicant for service, and in other cases any abnormal condition, former grave illness, or serious injury not inconsistent with present bodily vigor shall be entered on Form X (rough).

2079. Recruits presenting themselves for enlistment in the naval service shall be rejected by the examining surgeon for any one of the following conditions:

General Disqualifications

(*a*) *Mental Infirmities.*—Insanity, idiocy, imbecility, dementia.

(*b*) *Moral Infirmities.*—Intemperance in the use of stimulants or narcotics, evidence of felony, masturbation, sodomy.

(*c*) *Diseases of the Cerebro-spinal System.*—Epilepsy, chorea, all forms of paralysis, tabes dorsalis, neuralgia, stuttering.

(*d*) *Constitutional Diseases.*—Feebleness of constitution (poor physique), syphilis.

Special Disqualifications

(*e*) *The Skin.*—All chronic, contagious, and parasitic diseases of the skin, extensive nevi, deep and adherent cicatrices, chronic ulcers, vermin.

(*f*) *The Head.*—Abnormally large head; considerable deformities, the consequence of fracture; serious lesions of the skull, the consequence of complicated wounds or the operation of trephining; caries and exfoliation of the bone, injuries of cranial nerves, tinea capitis, alopecia.

(*g*) *The Spine.*—Caries, spina bifida, lateral or angular curvatures of the cervical, dorsal, or lumbar regions; lumbar abscess, rickets, fracture and dislocation of the vertebræ, angular curvatures, including gibbosity of the anterior and posterior parts of the thorax.

(*h*) *The Ears.*—Deafness of one or both ears, all catarrhal and purulent forms of acute and chronic otitis media, polypi and other growths or diseases of the tympanum, labyrinth, or mastoid cells; perforation of the tympanum; closure of the auditory canal, partial or complete, except from acute abscess, furuncle, or impacted cerumen; malformation or loss of the external ear and all diseases thereof, except those which are slight and non-progressive.

(*i*) *The Eye.*—Loss of eye, total loss of sight of either eye, conjunctival affections, including trachoma, entropion; opacities of the cornea, if covering a part of a moderately dilated pupil; pterygium, if extensive; strabismus, hydrophthalmia, exophthalmia, conical cornea, cataract, loss of crystalline lens, diseases of the lacrimal apparatus, ectropion, ptosis, incessant spasmodic motion of the lids, adhesion of the lids, large encysted tumors, abscess of the orbit, muscular asthenopia, nystagmus. Any affection of the globe of the eye or its contents; defective vision, including anomalies of accommodation and refraction; myopia, hypermetropia, if accompanied by asthenopia, astigmatism, amblyopia, glaucoma, diplopia, color blindness.

(*j*) *The Face.*—Extensive nevi, unsightly hairy spots, extensive cicatrices on the face.

(*k*) *The Mouth and Fauces.*—Harelip, simple, double, or complicated; loss of the

whole or considerable part of either lip; unsightly mutilation of the lips from wounds, burns, or disease; loss of the whole or part of either maxilla, ununited fractures, ankylosis, deformities of either jaw interfering with mastication or speech, loss of certain teeth, cancerous or erectile tumors, hypertrophy or atrophy of the tongue, mutilation of the tongue, adhesion of the tongue to any parts, preventing its free motion; malignant diseases of the tongue, chronic ulcerations, fissures or perforations of the hard palate, salivary or bucconasal and thyroglossal fistulæ, hypertrophy of the tonsils sufficient to interfere with respiration or phonation, pyorrhœa.

(*l*) *The Neck.*—Goiter, adenitis of the cervical glands, tracheal openings, thyroglossal or cervical fistulæ, wry neck, chronic laryngitis, or any other disease of the larynx which would produce aphonia, stricture of the esophagus.

(*m*) *The Chest.*—Malformation of the chest, or badly united fractures of ribs or sternum sufficient to interfere with respiration; caries or necrosis of ribs, deficient expansive mobility, evident predisposition to tuberculosis, chronic pneumonia, emphysema, chronic pleurisy, pleural effusions, chronic bronchitis, asthma, organic disease of the heart or large arteries, serious protracted functional derangement of the heart.

(*n*) *The Abdomen.*—All chronic inflammations of the gastro-intestinal tract, including diarrhea and dysentery; diseases of the liver or spleen, including those caused by malarial poisoning, ascites, obesity, dyspepsia, if confirmed; hemorrhoids, prolapsus ani, fistula in ano, considerable fissures of the anus, hernia in all situations.

(*o*) *Genito-urinary Organs.*—Any acute affection of the genital organs, including gonorrhea, syphilis, and venereal sores; loss of the penis, phimosis, if complete, stricture of the urethra, loss of both testicles, undescended testicle or permanent retraction of one or both testicles, chronic disease of the testicle or epididymitis, hydrocele of the tunic and cord unless the hydrocele of the cord is small and inconsequent, atrophy of the testicle, varicocele, malformations of the genitalia, epispadias, hypospadias, but a slight degree of hypospadias not preventing the normal passage of urine may not cause rejection; incontinence or retention of urine, urinary fistulæ, enlargement of the prostate, calculus, cystitis, and all organic diseases of the kidney.

(*p*) *Affections Common to Both the Upper and Lower Extremities.*—Chronic rheumatism, chronic diseases of joints or movable cartilage, old or irreducible dislocations or false joints, severe sprains, relaxation of the ligaments or capsules of joints, dislocations, fistulæ connected with joints or any part of bones, effusions into joints, badly united or non-united fractures, defective or excessive curvature of the long bones, rickets, caries, necrosis, exostoses, atrophy or paralysis of a limb; extensive, deep, or adherent cicatrices, especially of burns, contraction or permanent retraction of a limb or portion thereof, loss of a limb or portion thereof, inequality, deformities.

(*q*) *The Upper Extremities.*—Fracture of the clavicle, fracture of the radius and ulna, webbed fingers, permanent flexion or extension of one or more fingers, as well as irremediable loss of motion of these parts; mutilation or loss of either thumb, total loss of the index-finger of the right hand, loss of the second and third phalanges of all fingers of either hand, total loss of any two fingers of the same hand.

(*r*) *The Lower Extremities.*—Varicose veins, knock-knees, clubfeet, flat feet, webbed toes, the toes double or branching, the great toe crossing the other toes, hammer toe, bunions, corns, overriding or superposition of any of the toes to an extreme degree, loss of a great toe, loss of any two toes of the same foot, permanent retraction of the last phalanx of any of the toes, or flexion at a right angle of the first phalanx of a toe upon the second, with ankylosis of the articulation; ingrowing of the nail of the great toe, bromidrosis.

2080. (*a*)—TABLE OF PHYSICAL PROPORTIONS FOR HEIGHT, WEIGHT AND CHEST MEASUREMENT OF ADULTS

[Bureau of Navigation Circular relating to the enlistment of men, July 20, 1912]

Height	Weight	Chest (mean circumference)
Inches	*Pounds*	*Inches*
64	128	33
65	130	33
66	132	33½
67	134	34
68	141	34½
69	148	34¾
70	155	35¼
71	162	36
72	169	36¼
73	176	36¾

(*b*) —TABLE OF PHYSICAL PROPORTIONS FOR ENLISTMENT OF FILIPINOS

Age	Height	Weight	Chest measurement (mean)	Expansion
18 to 19	61	105	30½	2
20 to 21	62	108	31	2¼
22 and over.	62½	110	31½	2½

2081. The minimum height for acceptance of a man twenty-one years old or over is 64 inches barefooted. A variation not exceeding 1 inch is permissible if the applicant is in good health and desirable as a recruit. The minimum weight for acceptance of a man twenty-one years old is 128 pounds. A variation of 10 pounds, not to fall below 128 pounds in weight or 2 inches in chest measurement below the standard given in the table is admissible when the applicant for enlistment is active, has firm muscles, and is evidently vigorous and healthy, except for enlistment in the rate of coal passer, for which rate full standard measurements will be required. A chest expansion of less than 2 inches in a minor, or of less than

2½ inches in an adult, is a sufficient cause for rejection of an applicant. The table is given to show what is regarded in deciding upon the acceptance of recruits.

2082. A minor enlisting as apprentice seaman must conform to the standards noted in the following table, which is also applicable to apprentice musicians, United States Marine Corps, and to midshipmen. (Circular of July 20, 1912.)

	Minimum height	Minimum weight	Chest expansion
	Inches	*Pounds*	*Inches*
At 17 years of age	62	110	2
At 18 years of age	64	115	2
At 19 years of age	64	120	2
At 20 years of age	64	125	2

(If the age is six months in excess of a full year the requirements are those of the age at the next birthday.)

(No underweight or underheight is allowed in minors.)

2083. Marked disproportion of weight over height is not a cause for rejection unless the applicant is positively obese.

2084. Any one of the following conditions will be sufficient to cause the rejection of an applicant (Bureau of Navigation Circular, 1916):

(*a*) Feeble constitution, general poor physique, or impaired general health.

(*b*) Any disease or deformity, either congenital or acquired, that would impair efficiency, such as: Weak or deranged intellect, cutaneous disease not of a mild type, parasites of the skin or its appendages, deformity of the skull, abnormal curvature of the spine, torticollis, inequality of upper or lower extremities, inefficiency of joints or limbs, deformity of joints or bones (either congenital or the result of disease or injury), evidence of epilepsy or other convulsions, defective vision (minimum $^{15}/_{20}$ S. in either eye), disease of the eye, color blindness, impaired hearing or disease of the ear, chronic nasal catarrh, ozena, polypi, great enlargement of the tonsils, impediment of speech, disease of heart or lungs or predisposition to such disease, enlarged abdominal organs or evidence of cirrhosis, tumors, hernia, undescended testicle, large varicocele, sarcocele, hydrocele, stricture, fistula, hemorrhoids, large varicose veins, disease of the genito-urinary organs, chronic ulcers, ingrowing nails, bad corns, large bunions, deformity of toes, loss of many teeth, or teeth generally unsound (teeth properly filled not to be considered unsound). Every recruit must have at least 20 sound teeth.

(*c*) Any acute disease.

2085. (*a*) Each recruit shall be required to take the oath of allegiance, and further state that the statement he makes regarding his date of birth and previous naval or other military service is correct, and that he is not subject to fits, has no disease concealed or likely to be inherited, and has no stricture or internal piles. The examining surgeon certifies on the service record as follows: "I certify that I have carefully examined, agreeably to the Regulations of the Navy, the above-named recruit, and find that, in my opinion, he is free from all bodily defects and mental infirmity which

would in any way disqualify him from performing the duties of his rating, and that he has stated to me he has no disease concealed or likely to be inherited."

(*b*) (1) On account of insufficient or inaccurate information in reports of rejection as to physical defects of applicants for enlistment, the bureau is frequently unable to determine whether such defects should be waived, and such reports are often returned for further information before recommendation can be made.

(2) When a defect is curable by minor operation, the medical examiner should so state and also whether the applicant agrees to operation if necessary.

(3) In reporting rejections for any of the following defects the bureau desires that the information as noted below be given:

(4) *Flat Foot.*—Give degrees of flatness, stating accurately the distance between the tubercle of the scaphoid and the line from the lower border of the internal malleolus to the lower tubercle on the head of the first metatarsus. The measurement should be taken standing with the weight of the body on that foot and when the foot is at a right angle to the leg and the second toe is on a line with the crest of the tibia. The size of the shoe should also be given. The width of the ball of the foot should be given and any tendency to talipes valgus noted.

(5) Bunions, hammertoes, corns, and ingrowing toenails should be described accurately as to location, degree, etc.

(6) *Varicocele.*—State size and indicate by small, medium, or large.

(7) *Varicose Veins.*—State location, extent, and size and indicate by small, medium or large.

(8) *Hemorrhoids.*—State character and size and indicate by small, medium, or large.

(9) *Hydrocele.*—State size and indicate by small, medium, or large.

(10 *Hernia.*—State location, size, and whether incipient, incomplete, or complete. Relaxed rings only are not cause for rejection unless abdominal walls are weak or there is a decided impulse on coughing.

(11) *Deformities.*—State location, character, degree, and amount of interference with motion.

(12) *Contractures.*—State location, degree, and amount of interference with motion.

(13) *Stiff Joint.*—State location, degree of flexion and extension obtainable and the strength of the part.

(14) *Defective Hearing.*—State degree, giving distance by watch, by the whispered and spoken voice, stating whether he can readily hear ordinary conversation. State condition of the external canals and drums.

(15) *Defective Vision.*—State defect accurately, whether due to refractive error or other disease; when practicable, giving correction by lenses.

(16) *Missing or Defective Teeth.*—State in detail those missing or unerupted and those defective, using diagram for that purpose. Also state whether teeth will admit of proper repair.

(17) *Deficient Height or Weight.*—Always state age, height, and weight.

(18) *Tachycardia.*—State cause, character, and duration, giving time during examination for applicant to recover from excitement or overexertion.

(19) *Spinal Curvature.*—State location, character, and degree.

(20) *Atrophy or Hypertrophy of Testicle.*—State degree and cause.

2086. (*a*) Recruits shall be vaccinated within twenty-four hours after their arrival on a receiving ship or at a barracks. In case of failure the operation shall be repeated in eight days. If the second vaccination is not successful it shall be repeated at the first opportunity with a vaccine of assured potency. The only acceptable evidence of successful vaccination is a *pitted* scar following vaccination. Results of vaccination shall be recorded on the health record and reported on the quarterly report of sick.

(*b*) No recruit in the Navy or Marine Corps shall be transferred from a training station, receiving ship, barracks, or other rendezvous until the medical officer is satisfied that the man is protected against smallpox.

(*c*) Every enlisted man of the Navy or Marine Corps shall be vaccinated upon reënlisting, or extending enlistment, unless (a) he has two *pitted* vaccination scars, or (b) shows evidence of a previous attack of smallpox.

(*d*) Every officer should be vaccinated upon appointment immediately upon reporting at his first station for duty, and the fact entered on his health record. Revaccination should be performed at least once in every seven years thereafter unless he has two *pitted* vaccination scars, or evidence of a previous attack of smallpox. The responsibility for revaccination shall rest upon the medical officer making the annual physical examination required by I 709 (5). If it is impracticable for this medical officer to perform the vaccination, he shall notify the proper medical officer, through official channels, so that it may be carried out. The medical officer who performs the vaccination shall note the result of the vaccination on the officer's health record. (I 3211.)

2087. (*a*) Typhoid prophylactic shall be administered to all persons upon their first entry into the Navy or Marine Corps.

(*b*) It shall be administered to each enlisted man upon each subsequent enlistment, or extension of enlistment, who is under forty-five years of age, or who has not had a well-defined case of typhoid fever. The medical officer making the physical examination at the time of reënlistment shall start the administration, if practicable; if not, he shall notify the proper medical officer, through official channels, so that the administration may be completed.

(*c*) The administration of typhoid prophylaxis should be repeated after a period of four years for all persons in the Navy or Marine Corps who are under forty-five years of age, or who have not had a well-defined case of typhoid fever, and the medical officer making the annual physical examination required by Article I 709 (5) shall be responsible for its administration. If it is impracticable for him to give the prophylactic, he shall notify the proper medical officer, through official channels, so that it may be given.

(*d*) The only acceptable evidence of administration of the prophylactic shall be the entry on the health record, signed by the medical officer. (I 3212.)

2088. Medical officers are required by act of February 16, 1914, to conduct a physical examination of men of the Naval Militia when mustered into service of the United States. (General Order No. 150, June 14, 1915.)

2089. When available, medical officers will make such examinations of members of the Naval Auxiliary Service as are prescribed in the regulations for that service

Instructions to be Observed in Opening and Preparing Health Records

2241. (*a*) The whole name (Christian, middle, and surname), to correspond with that on service record and to be legibly written out, without abbreviations, and correctly spelled, preference being given to the original spelling of foreigners' names, the surname to precede and to be distinguished by being underlined.

(*b*) As far as possible, on reports and returns, the grades and rates of officers and men should be spelled out in full, but where sufficient space is not provided the abbreviations in par. 2241 (*b*) of the manual should be used.

(*c*) Enter the rating in which actually enlisted.

(*d*) Enter the name of the place where enlisted.

(*e*) Enter date actually enlisted and strike out the term not to be used as not applying in the case of the man under consideration, following the date of enlistment.

(*f*) Enter month, day, and year of birth.

(*g*) Specify city, town, or other locality of birth, whatever the nationality.

(*h*) Enter (from recruit's statement) all former diseases and injuries.

(*i*) Give former occupation or occupations.

(*j*) For enlisted persons give the number of continuous-service certificate and years of previous service.

(*k*) Give name and address of nearest relative or friend.

(*l*) Enter religion.

(*m*) Eyes: Blue, gray, blue-gray, yellow-gray, hazel (light brown), dark brown, bicolored (as when the pupillary border is of a different color from rest of iris); also state when the two eyes are of different colors.

(*n*) Hair: Flaxen, sandy (yellowish red), auburn (reddish brown), brown (light, dark, or very dark), black; also whether thin, bald, straight, curly, or woolly.

(*o*) Complexion is not to be described as simply "light" or "dark," but the character and degree shall be as accurately stated as possible; as complexion, pallid, sallow, fair (only when decidedly clear), ruddy, florid, dark (tawny, sunburnt, or tanned), very dark (swarthy or dusky), mulatto, negro.

(*p*) Height to be expressed in inches; the body to be erect, the chin neither elevated nor depressed, the feet and knees touching, legs stiff, and arms hanging perpendicularly.

(*q*) Weight, body nude, or allowance made for clothing worn. Accuracy of scales to be ascertained before using.

(*r*) Vision to be expressed as a fraction, of which the numerator will be the distance at which Snellen's 20-foot test can be determined, and the denominator 20.

(*s*) Hearing is to be expressed as a fraction, of which the numerator will be the distance in feet a whispered voice can be heard, and the denominator 15.

(*t*) Circumference of thorax to express the mean of the greatest circumference after forced inspiration and of the least after forced expiration, measured by a tape-line horizontally at the precise level of the nipples; the difference between the greatest and least circumference to be entered as expansion.

(*u*) Teeth missing or useless shall be indicated by marking the dental formula as noted.

(*v*) Remarks: Note any prominent physical trait not inconsistent with bodily vigor or not in such degree as to constitute cause for rejection—leanness or the

reverse; hirsuteness; slight asymmetry of body or limbs, knock-knees, bow-legs, or flat feet; peculiarities of teeth and genitalia; slight varicocele, etc. In this connection examiners are to remember that imperfections that might pass in a man should reject boys.

(*w*) Marks and scars should be indicated as required on the printed outline figure.

(*x*) Enter the date and nature of any waiver requested.

(*y*) Finally sign the record in the space provided. Corrections made subsequent to enlistment to be entered in red ink and initialed.

2242. This record shall be prepared for each officer and enlisted man of the Navy and Marine Corps and for members of the Nurse Corps.

Identification Records and Finger Prints

Identification records, consisting of finger prints and personal descriptions, will not hereafter be forwarded to the Bureau of Navigation upon the reënlistment of men if the date of last enlistment was subsequent to January 1, 1907, or upon discharge for undesirability, bad conduct, or with dishonorable discharge if enlisted subsequent to that date.

The files of finger prints, which were inaugurated January 1, 1907, are now practically complete for the term of enlistment provided by law, and in future it will only be necessary to forward finger prints and personal descriptions in the following cases:

On first enlistment.

On reënlistment from the Army or Marine Corps.

On reënlistment when date of last enlistment was prior to January 1, 1907.

Upon discharge as undesirable or with bad conduct or dishonorable discharge if the enlistment occurred prior to January 1, 1907.

In future it will only be necessary to forward identification records in the following cases to headquarters, United States Marine Corps:

Upon application for first enlistment.

Upon reënlistment from Army or Navy.

Upon reënlistment from the Marine Corps when date of last enlistment was prior to January 1, 1908.

Upon discharge as undesirable or with bad conduct or dishonorable discharge if the enlistment occurred prior to January 1, 1908.

Identification records will not hereafter be forwarded upon the reënlistment of men if the date of last enlistment was subsequent to January 1, 1908.

Outline Figure Card and Descriptive List

[From Chap. 12, Manual for the Medical Department]

2101. The outline figure on the reverse side of the finger-print record shall be filled out in the case of every recruit that has been found physically qualified and accepted for enlistment and for every sailor or marine who presents himself for reënlistment when date of last enlistment was prior to January 1, 1907.

2102. Medical officers on recruiting duty shall observe the greatest care in the preparation of these cards and shall exercise every care that the record on each card may be complete.

2103. The medical officer shall make a careful and systematic examination of the body of the man, front and rear, on each side of the median line, separately, commencing at the scalp and ending at the foot, and the following directions shall be carefully noted:

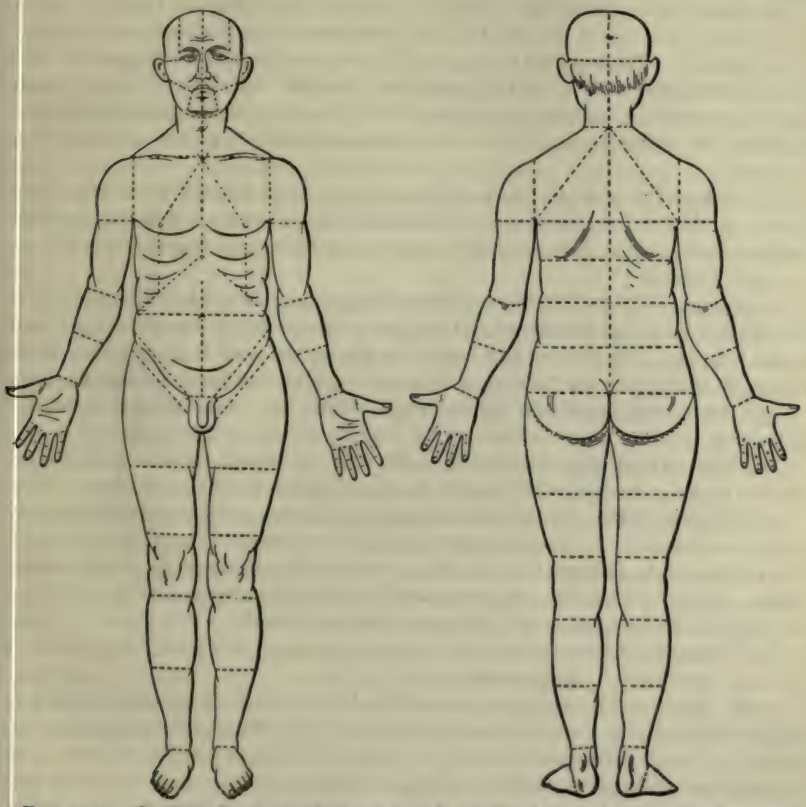


FIG. 143.—Outline figure card upon which deformities, injuries, scars, moles and marks may be indicated and described.

(*a*) Cards showing less than five marks in addition to vaccination scars, tattooing, loss of teeth, and deformities (which should likewise be noted) cannot be relied upon in the effort to discover identity or to identify a person in suspected cases. Experience shows that as many as 10 or 15 marks may usually be found.

(*b*) If no marks be found upon the recruit, the fact should be stated upon both the front and back of the card. If marks are found upon the front and none upon

the rear, or *vice versa*, the entry "no mark" should be made upon the appropriate side of the card.

(*c*) Outline figure cards are to be made out in permanent black ink. Copying ink or indelible pencils should not be used.

(*d*) Name.—Christian and middle name in full and surname in the order to be used. The name should be written very plainly, or preferably typewritten or printed in plain gothic letters.

(*e*) Rate.—The rate in which recruit is enlisted shall always be stated.

(*f*) Age.—The age at the time the card is prepared is the one that shall be given.

(*g*) Height.—The height is to be given in inches, and as it is relied upon as a base in comparing the cards of recruits with the classified descriptions of the former sailors or marines, and as the measurement may to a considerable degree be affected by efforts at deception on the part of the recruit, great care in ascertaining it is enjoined.

(*h*) Hair.—The scale of hair colors may be given as follows: Flax color; light brown; of red hair, as follows: brick red, sandy red, auburn (reddish brown); dark brown; black; of gray hair, as follows: dark gray, light gray (approaching white), iron gray (mixed).

(*i*) Eyes.—The eyes should be compared by placing the subject with the face in good light. Slide the Standard Eye Chart up or down the left side of the face, close to the left eye. The nearest approach in similarity of color is the number to be given. If the right eye is distinctly different in color, its number also should be given.

(*j*) White or Colored.—Write the word "white" or "colored" to indicate race as the case requires. Do not indicate by crossing out one of the words.

(*k*) Date of Last Prior Enlistment in the Navy or Marine Corps.—If the recruit has had no prior service in the Navy or Marine Corps, write the word "none."

(*l*) Missing Teeth.—To indicate the missing or useless teeth, mark with an X the letters corresponding to the teeth that are absent or useless. Teeth that are partly decayed should be indicated by drawing a diagonal line through the corresponding letters. If none are missing, write the word "no" in front or above the words "missing teeth." This will show that they were not overlooked.

(*m*) Station and Date.—Write the name of the station at which the card is made out and the date of its preparation.

2104. Marks on the outline figure card should be made at points corresponding to those occupied by the marks on the body of the recruit. This may readily be accomplished by drawing imaginary lines on the body of the recruit like the dotted lines on the card and placing the mark in the proper position on the card. As the dotted lines mark the boundaries of regions which are used in the systematic arrangement of the cards for purposes of identification, it is important that each mark on the card should be placed in its proper position.

(*a*) A pen picture is desired of all marks, showing their inclination and general shape. In the case of tattoos, this is optional.

(*b*) A straight line should be drawn from each mark to its description on the right or left of the figure. When avoidable, these lines should not cross each other.

(*c*) When a description is common to a number of marks, it need not be repeated for each one, but the lines may converge to it, if they can do so without crossing others.

(*d*) The sizes of all scars, moles, warts, birthmarks, etc., are to be given in inches or fractional parts thereof, except in the case of pinhead moles (abbreviation p. m.).

(*e*) Pinhead moles are moles less than one-eighth of an inch in diameter.

(*f*) Tattoo marks should invariably be noted and described in detail as they appear. In the case of devices composed of two or more figures, the component parts should be named, *e.g.*, "heart, cross, and anchor," not "faith, hope, and charity;" "clasped hands," not "friendship;" "eagle, shield, crossed cannon, flags, and arrows," not "American coat of arms." The same applies to all emblems, coats of arms, lodge pins, badges, etc.

(*g*) Letters, initials, and words should be printed, by hand, in plain roman capitals or gothic, thus; " J. M. H.," "U. S. V.," "I. X. L.," "IN GOD WE TRUST," etc.

(*h*) Details of costume, posture, and relationship to other devices should be given in the case of tattooed representations of men and women, *e.g.*", woman clinging to a cross;" "man and woman embracing, houses, lighthouse, and ship in the background;" "sailor standing by a tombstone, weeping willow overhead, cap in right hand, words 'in memory of my mother' on stone."

(*i*) The size of tattoos need be given only in the case of dots, blotches, circles, lines, etc.

(*j*) It is not necessary to state the color or kind of pigment used in the tattooing.

(*k*) Do not crowd the description of tattoos between the right arm of the figure and the edge of the card in front, nor the left arm and edge of the card on the back.

(*l*) Indecent or obscene tattooing is cause for rejection, but the applicant should be given an opportunity to alter the design, in which event he may, if otherwise qualified, be accepted.

(*m*) Do not write on the figure. The figure is to be used only for the purpose of locating, by pen pictures, the different marks found on the body of the recruit.

(*n*) Amputations and losses of parts of fingers and toes should be noted, showing the particular member injured and how much of it is gone.

2105. The following abbreviations are authorized and will be understood in the sense indicated, viz.: Amp., amputation; bl., blue; bmk., birthmark; bro., brown; d., depressed (except when following a dimension; then it stands for diameter); f., flat; fl., fleshy; h., hairy; m., mole; p., pitted; p. m. pinhead mole; r., raised; s., scar or smooth; v., vaccination; var., varicose veins or varicocele; w., wart.

(*a*) All combinations of these abbreviations are admissible, *e.g.*, p. s. ½ d., pitted scar ½ inch in diameter; s. 1, scar 1 inch long; f. p. s. 1 x ½, an oval, flat, pitted scar, 1 inch long and ½ inch wide.

(*b*) Abbreviations denoting shape are unnecessary, for the letter "d" following a dimension shows that the mark is circular. Two dimensions given indicate that the mark is oval or oblong, and when no letter follows the dimension it is understood that the mark or scar is linear.

(*c*) When a linear mark or scar is otherwise than straight the length to be given is the shortest distance from one extreme to the other.

(*d*) The letters "T. M." should not be used as abbreviations for "Tattoo marks," as they are liable to be taken for tattooed letters on the person.

Finger Prints

The apparatus for taking finger prints consists of a form holder, an ink plate, and a roller for spreading the ink on the plate.

Keep the roller and ink plate clean and free from dust, grit, or hairs, and the ink tube closed when not in use. When the day's work is finished, clean the ink from the plate and roller by means of a cloth and benzene. When not using the roller, rub it with a little sweet oil or lubricating oil before laying it away, to prevent the composition from becoming too hard.

Preparatory to taking finger prints squeeze a *small quantity of ink* from the tube and carefully work it, by use of the roller, into a thin film on the plate, the spreading of which may be facilitated by frequently turning over the roller. *If too much ink is used, the impression will be blurred and consequently unsatisfactory.* The thickness of the ink after being spread on the plate should be less than one-half the elevation of the ridges, and this can be tested by taking impressions.

The recruit should wash his hands thoroughly with soap and brush, using, if practicable, running water, especial care then being taken to rinse off all soap or lather with cold water. Failure to do this will cause white blotches to appear in the impressions. Immediately before placing the fingers on the inked plate the fingers should be well wiped with a cloth dampened with benzene or ether, which should remove all trace of grease, water, or perspiration.

Two kinds of impressions are used, "plain" and "rolled." A plain impression is obtained by pressing the bulb of the finger, with the plane of the nail parallel to the plane of the plate, on the inked plate and then on the paper in the same manner. A rolled impression is obtained by placing the side of the finger on the inked plate, with the plane of the nail at right angles to the plane of the plate, and rolling the finger over from one side to the other until the plane of the nail is again at right angles to the plane of the plate, but with the bulb surface of the finger facing in the opposite direction, thus inking the surface of the finger, and then rolling the finger over the paper in the same manner, in this way obtaining a clear impression of the ridges on the surface of the finger. This latter impression should include both the palmar surface and the sides of the finger between the tip and the flexure of the last joint. Always roll the fingers from the awkward position to the natural position.

It is absolutely necessary that the finger prints shall be clear, that the ridges shall be distinctly outlined, and that the "rolled" impressions shall be sufficiently large to include all the points needed for accurate classification, and free from blur. Black impressions are better than light ones if the spaces between the ridges are free from blur.

When the skin of the fingers is in poor condition, make special effort to get best results.

Entire palmar surface of first joint should be inked so that whole contour of pattern will be shown when finger is rolled.

Recruit should first be required to sign his name, and then to roll the impression of the right index-finger in the space above his signature. This will eliminate entirely the possibility of the recruit signing other than his own identification record. Have only one recruit at a time present in the room where prints are being made, and com-

plete and file each record before the next man enters or is taken up. In this way no other record than the one in question is available or within reach of the recruit being recorded, therefore he can sign no record but his own. Do not allow records to lie around, but file or otherwise dispose of them at once after completing examination.

In taking impressions, the operator himself should manipulate the hands of the recruit, who should be directed to relax his fingers and not to attempt to assist by adding to the pressure on the inked plate or on the paper. In order that the ink may be taken up on the finger evenly and in sufficient quantity, an unused part of the plate should be selected each time for inking the finger, and when no unused part of the plate remains the ink should be redistributed with the roller or the plate reinked. See that there are no clots of ink where the fingers are to be rolled on the plate.

The form holder, which is intended to prevent the form from moving about and blurring the print while impressions are being taken, will be used. The best results will be obtained with a table that places the form holder at about the height of the elbow of the recruit when he is standing with his arms hanging at his sides. To place a form in the holder, press out the plate by means of the levers at the ends, place the form in position under the plate, and push back the levers to their original position. The pressure of the springs on the plate will hold the form firmly in position.

To record the finger prints on Bureau of Navigation Form No. 2 and United States Marine Corps Form N. M. C. 330, place one of the blank forms in the holder, with the upper heavy black line appearing just above the upper edge of the plate; then take the rolled impressions, in the order named and in proper spaces on the form, of the thumb, index, middle, ring, and little fingers of the right hand, the impressions to be located on the form so that the flexure of the last joint is immediately above the folding line. This will leave room for a second print to be taken in the upper part of the space in case the first print is defective.

After the impressions of the fingers of the right hand have been taken, move the form in the holder until the lower heavy black line appears just above the edge of the plate; then take the rolled impressions of the fingers of the left hand in the proper spaces on the form.

After the rolled impression of each finger of both hands has been obtained, again move up the form in the holder until the plate covers only enough of the lower edge of the form (not exceeding ¼ inch) to hold it in place. Then take a plain impression of the four fingers of the right hand at one time, the fingers being held together so as to bring the prints within the allotted space, and a similar plain impression of the fingers of the left hand. Below the finger impressions take a plain impression of each thumb.

The method of obtaining the plain impressions is to take each of the fingers in turn and place the *bulbs only* on the inked plate. When this is done, press the recruit's fingers together, and with his hand limp and flat (not bowed or arched) place it in the space shown on the form and press each finger at the base of the nail, lightly. No attention need be paid to the deltas in the plain simultaneous impres-

sions, but the detail must be clearly defined. These impressions are used to determine if the rolled impressions are in their proper sequence.

A finger should not be noted missing if any portion of it beyond the flexure of the terminal joint remains. The end of a mutilated finger should, in all cases, be inked and recorded as in the case of a perfect digit.

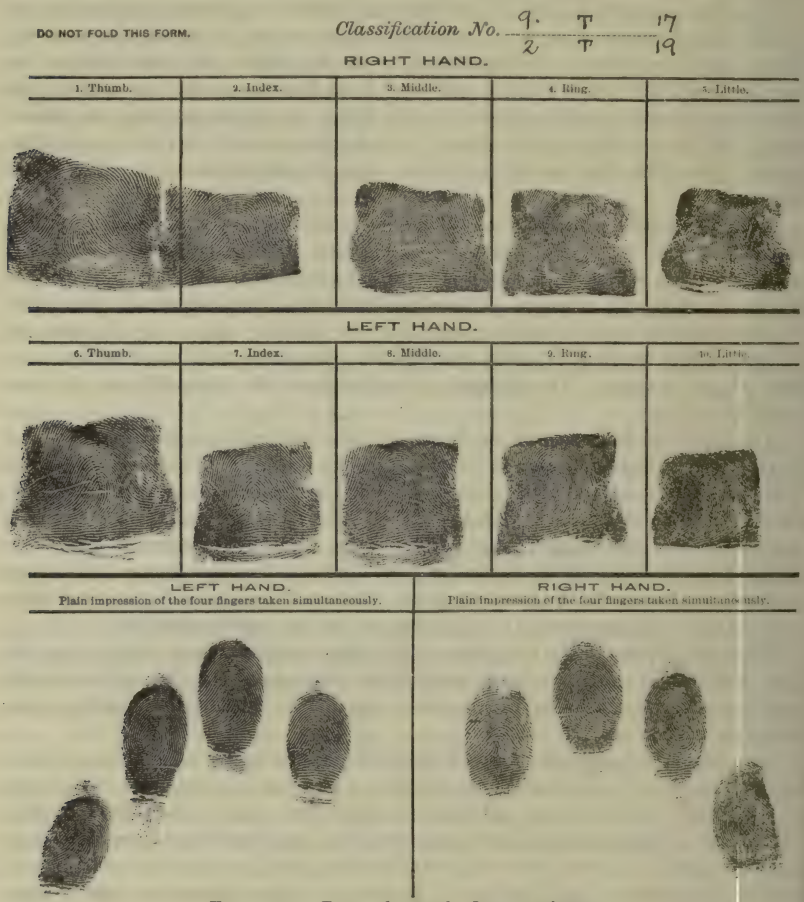


FIG. 144.—Properly made finger prints.

No amount of pressure by the operator should be used in making or inking rolled impressions. It is the pressure that causes the ink to more readily run in between the ridges. The finger tips should be allowed to touch the paper only with sufficient pressure to make a record.

The utmost care should be taken in recording the impressions of the little fingers. From these fingers a subclassification number is obtained.

When the finger-print side of the form has been completed, the impressions will be inspected to make sure that they are clear and free from blur; that all deltas are

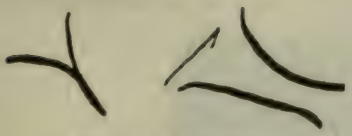


FIG. 145.—Deltas.

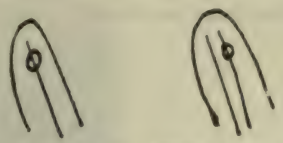


FIG. 146.—Cores of loops.

FIG. 147.—An arch.

FIG. 148.—A tented arch.

shown in the rolled impressions, and that the whole contour of the pattern is shown. The rolled impressions will also be compared with the plain impressions for the

purpose of ascertaining whether they are recorded in proper sequence. Any defective impressions will then be remedied by taking another print in the upper part of the proper space or by using a new form, if necessary. If the impressions are not recorded in proper sequence, a new form must be used, the old one being destroyed.

FIG. 149.—Radial loop, right hand, or ulnar loop, left hand.

After the finger prints have been taken and examined, the opposite side of the form will be filled out and the personal description completed by noting on the outline figures the principal identification marks.

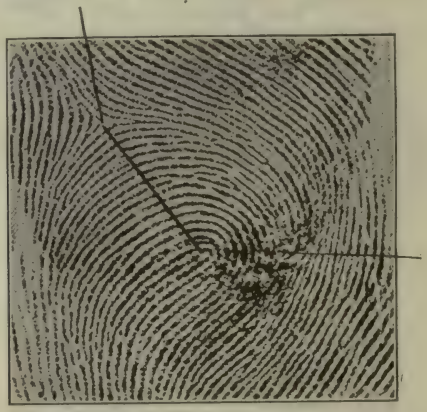


FIG. 150.—Ulnar loop, right hand, or radial loop, left hand.

Before making the entries on the personal description side of the blank, allow the ink on the finger-print side to become sufficiently dry to prevent blurring by rubbing. A few minutes will be sufficient if the form is handled carefully and not rubbed about on the desk while the personal description is being entered. A sheet

of blotting paper placed under the form will protect it to some extent. If an impression becomes blurred at any time, a new impression must be taken in the upper part of the proper space, or, if necessary, the imperfect form should be destroyed and a new blank used.

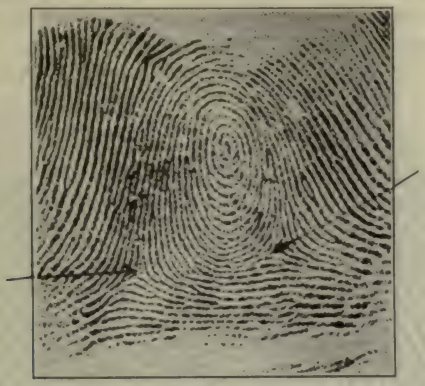


FIG. 151.—A whorl showing two deltas.

A delta may be formed by the bifurcation of a single ridge or by the abrupt divergence of two ridges that hitherto had run side by side (see Fig. 145).

The core of a loop may consist either of an even or uneven number of ridges not joined together (see Fig. 146).

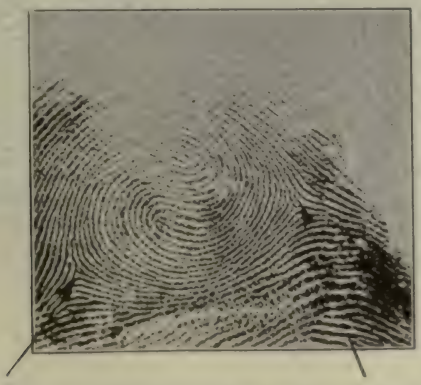


FIG. 152.—Composite, showing two deltas.

Arches.—In arches the ridges run from one side to the other, making no backward turn. Arches have no deltas (Fig. 147).

Tented Arches.—In patterns of the arch type the ridges near the middle may have an upward thrust, arranging themselves, as it were, on both sides of a spine or axis,

toward which adjoining ridges converge. The ridges thus converging give to the pattern the appearance of a tent in outline, hence the name tented arch. Tented arches have no deltas (Fig. 148).

In loops some of the ridges make a backward turn but without twist; there is one delta. If the downward slope of the ridges about the core is from the direction of the little finger toward that of the thumb it is a radial loop. Figure 149 is a radial loop in the right hand. The heavy black line drawn from the delta to the core indi-

FIG. 153.—Ulnar loop (right hand) showing 65 points of identification.

cates the ridges that are counted in classifying loops. In this impression the line cuts or crosses 16 ridges. If the downward slope of the ridges about the core is from the thumb side toward the little finger the loop is ulnar. Figure 150 is an ulnar loop in the right hand or a radial loop in the left hand. In this impression the heavy black line crosses 19 ridges. Be sure that the delta is shown if the impression is a loop.

Whorls.—In whorls some of the ridges make a turn through at least one com-

plete circuit. There are two deltas. Whorls are single cored or double cored (Fig. 151). The right and left deltas in this impression are shown by the arrowheads. The deltas in whorls must always be shown, in order that the tracings may be properly made. In whorls the ridge traced starts from the left delta and is traced toward the right delta. When the ridge whose course is traced meets the corresponding right delta ridge the whorl is specialized as M; when this ridge goes inside of the right delta with three or more ridges intervening it is specialized as I; when the ridge traced goes outside of the right delta with three or more ridges intervening it is specialized as O.

Figure 152 is a composite. This pattern is classed as a whorl and has two deltas. The right and left deltas in this impression are shown by the arrowheads.

Figure 153 shows ridge characteristics used in establishing the identity of a person. Unless an impression is free from blur great difficulty is encountered in picking out the points of comparison between two impressions. Sixty-five points of comparison are shown on this impression which are free from blur and could all be used for purposes of comparison and identification with another print of the same individual.

Each operator should instruct his relief in the taking of finger prints, so that the Bureau of Navigation and Marine Headquarters will be able to receive good finger-print impressions at all times.

The skin on the finger tips of the bodies of men which have been recovered from the water will be greatly wrinkled or shriveled, so that without some treatment the making of satisfactory prints may be difficult and even impossible. The way to overcome this is to inject water with a hypodermic syringe beneath the skin of the bulb of the finger. This will smooth out the skin for the impression.

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